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THE MARINE DEPOSITS OF THE ARABIAN SEA

AN INVESTIGATION INTO THEIR DISTRIBUTION AND BIOLOGY

BY

H. G. STUBBINGS, M.A., PH.D.(CANTAB.), B.SC.(LOND.)

WITH FOUR PLATES, FOUR CHARTS AND FIVE TEXT-FIGURES.

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I. INTRODUCTION.

Historical.

Our knowledge of the deposits of the Indian Ocean is due almost entirely to the work of Sir John Murray, the founder of this branch of oceanographical investigation, whose methods have long influenced subsequent investigators in this field,

The first charts to show the distribution of deposits in the Indian Ocean were those prepared by Murray (1889), and Murray and Renard (1891). These incorporated all the data then available from many sources. Compared with more recent charts these early attempts to portray the nature of the bottom are extremely speculative.

The next chart of the deposits in the Indian Ocean is that prepared by Murray and Philippi (1908), incorporating the results of their investigation of the materials collected by the Deutsche Tiefsee-Expedition and of other available material collected by survey and cable ships. As a result of the " Sealark " Expedition (1905), a further report was prepared by Murray (1909), giving lists of all expeditions and vessels that had obtained physical oceanographical data in the Indian Ocean. In it is summarized our knowledge of the depths and deposits of the Indian Ocean up to that time.

Subsequent to this paper, two reports have appeared on the deposits of the Bay of Bengal and Andaman Sea (Sewell, 1925) and the Laccadive Sea (Sewell, 1935*a*). During the world cruise of the " Dana " in 1928–30 a line of echo-soundings was run from Colombo to the Seychelles, crossing a ridge to which Schmidt (1932) gave the name " Carlsberg Ridge ", and which we now know to run from near Socotra in a south-easterly direction to near the Chagos Archipelago and then west of south as far as the Island of Rodriguez.

Apart from these three contributions no large advances in our knowledge of the topography and deposits of the Indian Ocean have been made since the " Sealark " report ; the distribution of the several deposits in the north-western area was known in broad outline only, and the topography was extremely problematical. In both respects considerable advances have been made by the work of the " John Murray Expedition ", and the topography is now known in some detail. In the present report the areas of the different deposits, as given by Murray, are, with slight alterations, confirmed. The degree of agreement between the new chart and that of 1909 is a striking tribute to the skill and insight of the late Sir John Murray in assessing the nature and value of the small and often insufficient samples of deposits at his disposal.

Collecting Gear.

The types of apparatus used for the collection of bottom samples are given in the description of the scientific equipment of the Expedition (Sewell, 1935*b*, p. 10). The most important are the following :

(i) *Driver sounding tube.*—This was of the standard pattern, and is fully described in ' Discovery Reports ', I, p. 211 (Kemp *et al.*, 1929), under the name of " Ekman-Nansen Sounding Rod ".

(ii) *Baillie sounding rod.*—This also was of the standard pattern, and is described in the above report (p. 210).

(iii) " *Bigelow* " *sounding rod.*—This was especially made for the Expedition. A description is given by Sewell (1935*b*, p. 10). Cores up to 5 feet long were obtained with this apparatus.

(iv) *Priestman grab.*—This grab was designed to cover an area of 0·5 sq. m. and was of a modified " Petersen " type. The chief modification is the provision of two wire closing ropes on the outside of the grab instead of the usual single chain working internally. By this arrangement the contents of the grab are not disturbed by the closure of the grab, but are received on board in the natural state.

MATERIALS.

185 deposit-samples were collected from 131 stations in the north-west area of the Indian Ocean by various forms of apparatus. The following summary (Table I) shows the material available for investigation and the means whereby it was obtained :

TABLE I.

Apparatus.	Number of samples.	Complete samples.	Mud samples.	Sifted samples.	Debris samples.
Bigelow tube	51	51	..	..	..
Priestman grab	42	28	6	7	1
Driver tube	7	7	..	..	..
Snapper lead	4	..	2	..	2
Baillie rod	3	3	..	..	..
Agassiz trawl	31	7	1	20	3
Otter trawl	8	1	1	1	5
Monegasque trawl	7	3	1	2	1
Triangular dredge	21	14	1	5	1
Rectangular dredge	6	..	1	1	4
Conical dredge	2	..	..	2	..
Miscellaneous	3	..	2	1	..
	185	114	15	39	17

In the above table " complete samples " are those in which a sample of mud and also a sample of the coarser material, sifted out from a large bulk of mud, is preserved. In the case of Bigelow cores, the column indicates the number of these only. " Mud samples " are intact (unsifted) material preserved in spirit. " Sifted samples " are samples of the coarse material separated from the mud. These were largely used to ascertain the relative proportions of the different organic constituents of the sediments. " Debris " samples are small amounts of mud removed from jars of specimens. These are of little value except for a few additional records of Foraminifera and other remains, and are only listed in the above table where they are the chief or only source of information for particular stations.

The depth distribution of the samples is as follows :

m.	Number of stations.	m.	Number of stations.
0–100	19	2000–3000	7
100–500	42	3000–4000	9
500–1000	19	4000–5000	8
1000–2000	26	Over 5000	1

Total stations, 131.

CLASSIFICATION.

The classification of the sediments used is as follows, the numbers indicating the number of stations at which each type was found ;

		Number of stations.
1. Grey mud and clay		12
2. Green and brown muds		50
3. Coarse deposits:		
(*a*) Sand	9	
(*b*) Rock	3	16
(*c*) Conglomerate	4	
4. Globigerina ooze		21
5. Pteropod ooze		8
6. Red clay		3
7. Coral deposits:		
(*a*) Mud	12	20
(*b*) Sand	8	
8. Doubtful (Sta. 115)		1
Total		131

The term " terrigenous deposits " has thus been avoided. It was used by Murray to include :

1. Shallow-water and littoral sands, gravels and muds.
2. The following deep-sea deposits :
   - Blue mud.
   - Red mud.
   - Green mud.
   - Volcanic mud.
   - Coral mud.

In the present work, " coral mud " and other coral reef deposits are regarded as distinct from true terrigenous deposits, as they are largely of organic origin. Furthermore, it seems likely that red clay will prove to be of similar origin to the deposits of the Continental margins, *i. e.* largely of terrestrial origin. As Murray considered red clay to be of pelagic or volcanic origin, I prefer not to use the term " terrigenous deposits " until the status of red clay is finally settled. The names of the various deposits grouped by Murray under this head are retained.

The positions of the samples examined are shown on Chart I. Where the stations occur very close together, as in the Maldives and off Ras al Hadd, several are frequently indicated by a single symbol. The following symbols have been used :

● Indicates a sample obtained by Bigelow tube, Driver tube or Baillie rod.
▲ Indicates a Priestman grab sample.
■ Indicates a sample obtained with a trawl or dredge.
✕ Indicates a debris sample where this alone represents a station.

The abbreviations used to denote the character of the deposit in some of the tables are those given in the " Station List " (Sewell, 1935*b*, p. 15) with the addition of the following two :

cs. Coarse.
gv. Gravel.

METHODS.

Previous authors have concentrated on the description of marine deposits largely from the mineralogical and chemical standpoint. Little attention has been given to the biological remains present in the sediments, except by Murray and Renard (1891), or to the relationship between the sediments and the fauna. In the present report an attempt has been made to remedy this omission.

In examining the materials, the method employed was to shake a sample up with water and sift it through a fine linen sieve with meshes approximately 160μ in diameter. In this way it was possible to separate the larger mineral particles and animal remains from the mud. Remains as small as single and broken chambers of *Globigerina* could be separated by this means. Very coherent muds and clays were first boiled in water, and potash added if necessary to break down the lumps. The coarse fraction remaining on the sieve was washed on to a filter-paper, dried and weighed. The fine mud, passing with the water through the sieve, was likewise filtered off, dried and weighed. Both weights were then expressed as a percentage of the whole.

The relative amounts of the different remains were obtained by taking a representative sample of the sifted material, sorting this into the several groups and determining the percentage by weight of each.

The animal components have not all been identified. The Pteropoda and the majority of the Foraminifera have been determined specifically. Corals, some few Polyzoa and various of the more obvious Mollusca have been referred to their genera. In most instances it was possible only to separate the remains into Lamellibranchiata, Gasteropoda or Scaphopoda owing to the fragmentary condition of the shells. Other remains have merely been classed in their phylum or order, except for a few rare instances where generic or specific names are given.

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II. DESCRIPTION OF THE DEPOSIT-SAMPLES.

In this section the following expressions have been used :

(*a*) Coarse material or sample :

This indicates a sample in which the fine or mud portion has been washed out and is not available for investigation.

(*b*) Incomplete sample :

A sample, usually obtained with a net, from which an unknown amount of the mud has been washed out during its passage to the surface.

(*c*) Debris :

This term is used in the same sense as in Table I (p. 34).

In the tables of this section the following expressions need clarifying :

(*a*) " Frequency " :

This indicates a relationship between the number of specimens or fragments of the different components, and thus bears no relationship to the percentage figures given in columns 3 and 4, which are calculated on weights. The following symbols are used : R, rare ; F, frequent ; C, common ; VC, very common ; A, abundant.

(*b*) " Other remains " :

Unless otherwise stated, under this term are included (1) carbonaceous matter and mineral grains ; (2) unidentifiable calcareous material ; and occasionally (3) animal fragments too rare for estimation separately. These latter are sometimes estimated, where all together form a sufficient quantity, as " Other animals ".

The classification and nomenclature of the Foraminifera adopted throughout is that given by Cushman (1928, 2nd ed., 1933), and used by Thalmann (1932) to rename the species illustrated in Brady's report on the Foraminifera of the " Challenger " Expedition.

Station 5 : Red Sea ; depth 938 metres ; Driver tube sample ; brownish-yellow calcareous mud (red-brown when wet) with abundant pelagic Foraminifera and some Pteropod fragments ; mud 85·9% ; organic remains 14·1%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides
Gl. dubia.
Globigerinoides rubra.
Globigerinoides sacculifera.
Globigerinella æquilateralis.
Orbulina universa.

Pteropoda.

Peraclis bispinosa.
Limacina bulimoides.
L. inflata.
L. trochiformis.
Creseis acicula.
Creseis virgula.
Hyalocylis striata.
Clio pyramidata.
Cavolinia longirostris.
Atlanta sp.

No specimens of *Pulleniatina obliquiloculata* or of *Globorotalia* spp. occur at this or the following station.

Benthic remains :—

One Foraminiferan, *Verneulina propinqua*, only, and a few otoliths are present.

Station 6 : Red Sea ; depth 1167 metres ; coarse Salpa dredge sample ; soft calcareous rock bottom with embedded species of Pteropoda.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.

Pteropoda.

Limacina inflata. *Diacria quadridentata.*
Creseis acicula. *Cavolinia longirostris.*
Cr. virgula. *Atlanta* sp.
Hyalocylis striata.

In addition a few Gasteropoda and small translucent Lamellibranch valves are present in the matrix. *Globigerina bulloides* and *Limacina inflata* occur in considerable numbers. Other organisms are rather rare.

Station 7 : Red Sea ; depth 260 metres ; coarse conical dredge sample ; terrigenous sand with numerous Pteropod shells.

Chief components.	Frequency.	% coarse material.
Foraminifera . .	C .	2·3
Corals . . .	R .	0·9
Echinodermata . .	R .	2·0
Crustacea . .	F .	3·4
Lamellibranchiata .	R .	4·2
Gasteropoda . .	F .	11·0
Pteropoda. . .	VC .	16·9
Scaphopoda . .	R .	0·4
Pisces . . .	F .	5·5
Other remains . .	VC .	53·4
		100·0

Pelagic remains :—

Foraminifera.

Globigerina bulloides. *Globorotalia menardii.*
Pulleniatina obliquiloculata.

Pteropoda.

Limacina inflata. *Diacria quadridentata.*
Creseis virgula. *Cavolinia longirostris.*
Hyalocylis striata. *Atlanta* sp.
Clio pyramidata.

Benthic remains :—

Foraminifera.

Textularia pseudocarinata. *Pyrgo sarsi.*
T. sagittula var. *fistulosa.* *Eponides haidingeri.*
Spiroloculina depressa. *Rotalia papillosa.*
Sp. grateloupi. *Miniacina miniacea.*

Other remains : Cirriped valves.

The majority of the Foraminifera are worn and broken Rotaliidæ and Miliolidæ. Other species are rare. The abundance of Cirriped valves is remarkable, terga, scuta and

carinæ of at least two species of *Scalpellum* and valves and compartments of *Balanus* spp. being present. Small solitary corals are common. Among the shells are a few larval *Triforis* (="*Limacina turritelloides*" of Boas).

Station 9: Red Sea; depth 245 metres; no deposit sample was retained. The following Foraminifera occurred among debris:

Homotrema rubrum.
Sporadotrema cylindricum.
Sporadotrema mesentericum.
Miniacina miniacea.

Station 10: Red Sea; depth 55 metres; no deposit sample was retained. The following Foraminifera occurred among debris:

Sigmoidella elegantissima.
Operculina granulosa.
Heterostegina depressa.
H. operculinoides.
Sorites marginalis.
Amphistegina radiata.
Planorbulinella larvata.
Carpenteria utricularis.
Homotrema rubrum.
Sporadotrema cylindricum.
Sp. mesentertcum.
Miniacina miniacea.

Station 14: Gulf of Aden; depth 1764 metres; Driver tube sample; green-brown mud with fine Pteropod fragments and Foraminifera; mud 88·7%; organic remains 11·3%.

Pelagic remains:—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinella æquilateralis.
Orbulina universa.
Globorotalia menardii.

Pteropoda.

Limacina inflata.
L. trochiformis.
Creseis sp.

One benthic Foraminiferan, *Spiroloculina depressa*, only was present.

Animal remains in this deposit are very small and rare. There is considerable organic matter and few mineral particles.

Station 15: Gulf of Aden; depth 1053 metres; Bigelow sample; green-brown terrigenous mud with some pelagic Foraminifera; mud 83·2%; organic remains 16·8%.

Pelagic remains:—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides rubra.
Globigerinoides sacculifera.
Globigerinella æquilateralis.
Globorotalia menardii.

Benthic remains:—

Foraminifera.

Quinqueloculina sp.
Robulus sp.
Uvigerina pygmæa.
Discorbis sp.

Other remains are very rare, and are represented by a few fragments of Pteropoda, *Atlanta* spp., shells and Echinoderm spines.

Station between 15 and 16 : Gulf of Aden ; depth ? ; fragmentary Driver tube sample ; green mud with Foraminifera ; mud 90·4% ; organic remains 9·6%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides conglobata.
Gl. rubra.
Gl. sacculifera.
Globigerinella æquilateralis.
Orbulina universa.
Pulleniatina obliquiloculata.
Globorotalia canariensis.
Gl. menardii.

Benthic remains :—

Foraminifera.

Dentalina communis.
Bulimina elegans.
B. pupoides.
B. pyrula.
B. subornata.
Uvigerina bifurcata.
Uvigerina schwageri.
Cancris auriculus.
Anomalina balthica.
Planulina wuellerstorfi.
Laticarinina pauperata.

The organic components are almost entirely Foraminifera. A very few remains of shells, Pteropoda and Echinoderm spines are present.

Station 16 : Gulf of Aden ; depth 186 metres ; Driver tube sample ; brown-green calcareous mud with some Foraminifera and Pteropod fragments ; mud 88·4% ; organic remains 11·6%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides rubra.
Orbulina universa.
Pulleniatina obliquiloculata.
Globorotalia menardii.

Pteropoda.

Cavolonia sp. (fragment).

Benthic remains :—

Foraminifera.

Clavulina sp.
Robulus sp.
Planulina ammonoides.
Bulimina aculeata.
Bulimina elongata.
B. ovata.
Uvigerina pygmæa.

The deposit appears to contain much organic matter and few mineral grains. Siliceous remains are absent and fæcal pellets abundant.

Station 17 : Gulf of Aden ; depth 854 metres ; Bigelow sample ; fine brown sandy mud ; mud 94·2% ; organic remains 5·8%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinella æquilateralis
Globorotalia menardii.

Pteropoda.

Limacina inflata.
Creseis acicula.
Cr. virgula.
Hyalocylis striata.
Clio pyramidata.
Diacria quadridentata.
Cavolinia sp.

The deposit contains much fine quartz sand. Remains of benthic organisms and siliceous organisms are absent.

Station 18 : Gulf of Aden ; depth 1375 metres ; Driver tube sample ; brown-green calcareous mud ; mud 84·7% ; organic remains 15·3%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Globigetinoides rubra.
Orbulina universa.
Pulleniatina obliquiloculata.
Globorotalia menardii.

Much organic matter is present. Siliceous remains and benthic organisms are unrepresented. Fæcal pellets are very abundant (see Pl. I, fig. 4).

Station 20 : Gulf of Aden ; depth 1132 metres ; Bigelow sample ; green calcareous mud with numerous Foraminifera and some Pteropoda ; mud 80·6% ; organic remains 19·4%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Globigerinoides conglobata.
Gl. rubra.
Orbulina universa.
Pulleniatina obliquiloculata.
Globorotalia menardii.

Pteropoda.

Creseis virgula.
Clio pyramidata.

Benthic remains :—

Foraminifera.

Pyrgo depressa.
Nodosaria consobrina var. *emaciata.*
Lagena sp.
Uvigerina sp.
Chilostomella ovoidea.

Some fæcal pellets and a few rare Gasteropod fragments are present. There is considerable organic matter present, but no siliceous organisms occur (see Pl. I, fig. 3).

Station 21 : Gulf of Aden ; depth 1518 metres ; Bigelow sample ; green calcareous mud ; mud 82·8% ; organic remains 17·2%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides rubra.
Pulleniatina obliquiloculata.
Globorotalia menardii.

Benthic remains :—

Foraminifera.

Quinqueloculina sp. *Bulimina ovata.*

Foraminifera and a few otoliths are practically the only remains present in this deposit. Much organic matter is present. A very few Radiolarian fragments are the only siliceous representatives.

Station 22 : Central Arabian Sea ; depth 3556 metres ; Bigelow sample ; white Globigerina ooze ; mud 87·4% ; organic remains 12·6%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides. *Pulleniatina obliquiloculata.*
Gl. dubia. *Globorotalia menardii.*
Globigerinoides sacculifera.

This is an almost pure Globigerina ooze, and no red clay residue is left on dissolving out the calcium carbonate. The Foraminifera are almost all fragmentary, and no benthic forms are present. Siliceous remains are plentiful and include *Lithocircus* and other Radiolaria, Poriferan spicules, and diatoms, including a few specimens of *Coscinodiscus* sp. Poriferan fragments are quite common.

Station 24 : Gulf of Aden ; depth 73–200 metres ; incomplete Conical dredge sample ; yellow sand and calcareous conglomerate. The sand is 86·4% calcareous, the remainder being mainly quartz particles.

Pelagic remains :—

Foraminifera.

Globigerina bulloides. *Globorotalia menardii.*

Pteropoda.

Limacina helicina. *Creseis acicula.*

Benthic remains :—

Foraminifera.

Textularia carinata. *Uvigerina pygmæa.*
Triloculina sp. *Rotalia* sp.
Robulus sp. *Miniacina miniacea.*
Vaginulina ? tricarinella.

In addition the following also occur : Poriferan spicules, Alcyonarian spicules, *Cellaria*, Crustacean skeletal fragments, Echinoderm spines, Gasteropod and Lamellibranch fragments. The majority of these remains are rare. The conglomerate collected with the sand consists of clusters of dead *Balani* (? *B. amphitrite*) overgrown with Lithothamnia and Serpulid tubes, pieces of calcareous rock composed of shell fragments in a white calcareous matrix, and pieces of shell and other rubble overgrown by Lithothamnia.

Station 26 : Gulf of Aden ; depth 2312 metres ; Bigelow and incomplete Agassiz trawl samples ; very fine, light fawn-grey calcareous mud with few organic particles ; organic remains *circa* 1–2%.

Chief components.	Frequency.	% coarse material.
Foraminifera	C	10·6
Polychæta	R	0·5
Echinodermata	R	1·2
Lamellibranchiata	R	1·1
Gasteropoda	R	0·5
Pisces	R	1·2
Unidentified	C	84·9
		100·0

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides sacculifera.
Globorotalia menardii.

Pteropoda.

Diacria quadridentata.
Cavolinia longirostris.
Atlanta sp.

Benthic remains :—

Foraminifera.

Rhabdammina abyssorum.
Rh. discreta.
Rh. linearis.
Crithionina pisum.
Cr. pisum var. *hispida.*
Marsipella cylindrica.
Storthosphæra albida.
Pilulina jeffreysi.
Hyperammina elongata.
H. friabilis.
H. lævigata.
Saccorhiza ramosa.
Reophax pilulifer.
Hormosina carpenteri.
H. globulifera.
Haplophragmoides subglobosum.
Clavulina communis var. *nudulosa.*
Pyrgo depressa.
P. murrhina.
Lenticulina reniformis.
Bulimina pyrula.
Rotalia beccarii.
Epistomina elegans.
Planulina wuellerstorfi.

Pteropoda.

Diacria quadridentata.
Cavolinia longirostris.
Atlanta sp.

The coarse material consists almost entirely of small aggregates of Foraminiferal and other fragments, apparently portions of worm-tubes. The Foraminifera are almost all benthic forms ; apart from these, organic remains are rare. In the foregoing table most of the Polychæte tubes are composed of *Globigerina* spp. and *Globorotalia* spp., and so are counted in with the Foraminifera. Only the non-foraminiferal tubes are classified separately ; these are not common. A few Poriferan spicules were the only siliceous remains observed.

Station 27 : Gulf of Aden ; depth 37 metres ; Otter trawl debris ; coarse shell, coral and quartz sand.

Benthic remains :—

Foraminifera.

Textularia agglutinans.
T. gramen.
Spiroloculina grateloupi.
Spirophthalmidium acutimargo.
Elphidium crispum.
El. macellum.
Ozawaia tongaensis.
Operculina granulosa.
Alveolinella boscii.
Bolivina simpsoni.
Chrysalidinella dimorpha.
Rotalia papillosa.
Amphistegina radiata.
Gypsina vesicularis.
Miniacina miniacea.

The rest of the material consists of Echinoderm spines, fragments of Polyzoa, Alcyonarian spicules, coral, *Halimeda* and molluscan fragments. A considerable amount of the fine material seems to be of molluscan origin. Pelagic remains are very rare and are represented by a few *Globigerina* fragments only. The sand contains about 6·2% of quartz, the rest being calcareous material, mainly of organic origin.

Station 28 : Gulf of Aden ; depth 201 metres ; Priestman grab samples ; green sandy mud with numerous Pteropod and shell fragments ; mud 25·3% ; organic remains 74·7%.

Chief components.	Frequency.	% coarse material.	% deposit.
Foraminifera	R	0·6	0·5
Polychæta	R	0·5	0·4
Echinodermata	A	22·8	16·9
Crustacea	R	1·2	0·9
Lamellibranchiata	VC	22·6	16·8
Gasteropoda	VC	23·6	17·5
Pteropoda	VC	19·1	14·2
Scaphopoda	F	2·7	2·4
Other remains	F	6·9	5·1
		100·0	74·7

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globorotalia menardii.
Tretomphalus bulloides.

Pteropoda.

Limacina bulimoides.
L. inflata.
Creseis acicula.
Cr. virgula.
Hyalocylis striata.
Clio pyramidata.
Diacria quadridentata.
Cavolinia longirostris.
Atlanta sp.

Benthic remains :—

Foraminifera.

Rhizammina algæformis.
Reophax sp.
Textularia conica.
T. pseudocarinata.
T. rhomboidalis.
Robulus denticuliferus,

Nodosaria vertebralis. *Ehrenbergina pacifica.*
Bolivina amygdalæformis. *Cibicides lobatulus.*
Uvigerina pygmæa. *C. refulgens.*
Rotalia sp.

Mollusca.

Ianthina sp. ? *Venus torresiana.*
Solarium sp.

Echinoderm remains are represented by very numerous Spatangoid spines, fragments of Echinoids and Ophiuroid "vertebræ". Fish otoliths and vertebræ and *Balanus* fragments occur. Small fæcal pellets are common. Siliceous organisms are represented by long, slender sponge spicules.

Station 29 : Gulf of Aden ; depth 2072 metres ; Bigelow sample ; light brown highly calcareous, friable mud ; mud 65·5% ; organic remains 34·5%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides. *Globigerinella æquilateralis.*
Gl. dubia. *Hastigerina pelagica.*
Globigerinoides rubra. *Orbulina universa.*
Gl. sacculifera. *Globorotalia menardii.*

Pteropoda.

Creseis acicula.

Benthic remains :—

Foraminifera.

Triloculina sp. *Bulimina ovata.*
Pyrgo murrhina.

Molluscan remains include small shells of Gasteropoda and Scaphopoda. Fæcal pellets are common. Poriferan spicules are fairly frequent and a few rare Radiolaria occur.

Station 32 : Gulf of Aden ; depth 1178 metres ; Bigelow sample ; green, calcareous mud with Foraminifera ; mud 84·1% ; organic remains 15·9%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides. *Globigerinella æquilateralis.*
Gl. dubia. *Orbulina universa.*
Globigerinoides rubra. *Pulleniatina obliquiloculata.*
Gl. sacculifera. *Globorotalia menardii.*

Pteropoda.

Cavolinia sp.

Benthic remains :—

Foraminifera.

Bulimina affinis. *Planulina ammonoides.*
Uvigerina pygmæa.

Fæcal pellets, Radiolaria and sponge spicules are all rare.

Station 33 : Gulf of Aden ; depth 1295 metres ; Bigelow and incomplete Agassiz trawl sample ; green, calcareous, coprolitic mud.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides rubra.
Gl. sacculifera.
Orbulina universa.
Pulleniatina obliquiloculata.
Globorotalia menardii.

The only benthic Foraminiferan identified was *Chilostomella ovoidea.* The deposit consists largely of fæcal pellets. Pelagic Foraminifera, fish scales and shell fragments are fairly common. Broken valves of *Amussium* sp. and shells of *Pleurotoma* were identified.

Station 34 : Gulf of Aden ; depth 1032 metres ; Bigelow and Agassiz trawl samples ; brown calcareous mud with fæcal pellets and Foraminifera ; mud 79·9% ; organic remains 20·1%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides rubra.
Globigerinella æquilateralis.
Hastigerina pelagica.
Orbulina universa.
Pulleniatina obliquiloculata.
Sphaeroidinella dehiscens.
Globorotalia canariensis.
Gl. menardii.

Pteropoda.

Limacina inflata.
Creseis virgula.
Hyalocylis striata.

Benthic remains :—

Foraminifera.

Spiroplectammina milletti.
Gaudryina pseudofiliformis.
Clavulina communis.
Sigmoilina schlumbergeri.
Robulus calcar.
Lenticulina rotulata.
Nodosaria scalaris.
Bulimina aculeata.
B. pupoides.
Uvigerina bifurcata.
U. schwageri.
Angulogerina carinata var. *bradyana.*
Rotalia beccarii.
Cancris auriculus.
Ehrenbergina pacifica.
Chilostomella ovoidea.
Planulina ariminensis.
Pl. wuellerstorfi.

A few broken Gasteropod and Dentaliid shells are the only large fragments present. The other remains are of the size of *Globorotalia menardii* or smaller. Small *Globigerina* are very common, followed by *Globorotalia* and fæcal pellets in that order. *Uvigerina* is common, but the other benthic Foraminifera are rare numerically, usually being represented by one or two specimens only.

Station 35 : Gulf of Aden ; depth 441 metres ; Bigelow sample ; brown-green calcareous, friable mud ; mud 68·6% ; organic remains 31·4%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides conglobata.
Gl. rubra.
Hastigerina pelagica.
Orbulina universa.
Pulleniatina obliquiloculata.
Globorotalia menardii.

Pteropoda.

Limacina inflata.
Creseis acicula.
Cr. virgula.
Diacria quadridentata.
Cavolinia tridentata.
Atlanta sp.

The benthic remains include only two species of Foraminifera, *Saracenaria italica* and *Bulimina* sp. Lamellibranch valves, *Cadulus* sp. and fæcal pellets also occur. The latter are common. Siliceous remains are absent.

Station 38 : Gulf of Aden ; depth 2458 metres ; Bigelow sample ; light fawn-grey calcareous mud with few macroscopic remains ; mud 95·1% ; organic remains 4·9%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides rubra.
Pulleniatina obliquiloculata.
Globorotalia menardii.

Benthic remains :—

Foraminifera.

Clavulina ? communis.
Pyrgo murrhina.
Bulimina aculeata.
Planulina wuellerstorfi.

No other calcareous remains are present. Siliceous remains include Poriferan spicule fragments, diatoms (*Coscinodiscus*) and a very few Radiolaria.

Station 39 : Gulf of Aden ; depth 2156 metres ; Bigelow sample ; fawn-grey calcareous mud ; mud 96·3% ; organic remains 3·7%.

Pelagic remains :—

Foraminifera.

Globigerina dubia.
Globigerinella æquilateralis.
Orbulina universa.
Pulleniatina obliquiloculata.
Globorotalia menardii.

Benthic remains :—

Foraminifera.

Pyrgo murrhina.
Nonion umbilicatulum.
Gyroidina soldani.
Planulina wuellerstorfi.

Poriferan spicules and Radiolaria are rare, but *Coscinodiscus* is fairly frequent.

Station 42 : South Arabian Coast ; depth 1415 metres ; debris and large fragments ; no complete sample of the deposit is available. The debris contained the following Foraminifera :

Globigerina sp.
Globorotalia menardii.
Rhizammina algæformis.

Station 43 : South Arabian Coast ; depth 95 metres ; no sample except debris containing :

Foraminifera.

Carpenteria monticularis.
C. proteiformis.
C. utricularis.
Sporadotrema cylindricum.
Sp. mesentericum.
Miniacina miniacea.

Station 45 : South Arabian Coast ; depth 48 metres ; coarse dredge and debris samples ; calcareous conglomerate and *Lithothamnion.*

Benthic remains :—

Foraminifera.

Textularia sp.
Quinqueloculina agglutinans.
Q. intricata.
Spiroloculina grateloupi.
Triloculina tricarinata.
T. trigonula.
Pyrgo anomala.
Carterina spiculotesta.
Nodosaria subscalaris.
Guttulina yabei.
Sigmoidella elegantissima.
Elphidium craticulatum.
El. crispum.
Operculina granulosa.
Heterostegina depressa.
Sorites marginalis.
Discorbis globularis var. *bradyi.*
Gyroidina soldani.
Eponides præcinctus.
Planopulvinulina dispansa.
Rotalia papillosa.
Amphistegina radiata.
Cibicides refulgens.
Planorbulinella larvata.
Gypsina globulus.
Sporadotrema cylindricum.
Sp. mesentericum.
Miniacina miniacea.

The material consists of large lumps of *Lithothamnion*-covered calcareous conglomerate. The usual encrusting organisms, such as Polyzoa, Polychæta and Foraminifera, are present. The coral *Pavona* occurs here. The following Polyzoa were identified : *Crisia* sp., *Hornera* sp., and *Cellepora* sp. Poriferan spicules were abundant, but Echinoderm and Alcyonarian spicules rare.

Station 50 : South Arabian Coast ; depth 1536–1939 metres ; dredge sample ; brown-green Foraminiferal mud ; mud 67·6% ; organic remains 32·4%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides rubra.
Gl. sacculifera.
Orbulina universa.
Pulleniatina obliquiloculata.
Sphæroidinella dehiscens.
Globorotalia menardii.
Gl. canariensis.

Benthic remains :—

Foraminifera.

Rhabdammina abyssorum.
Crithionina pisum var. *hispida.*
Cyclammina sp.
Sigmoilina schlumbergeri.
Polymorphina sp.
Nonion umbilicatulum,
Bulimina aculeata.
Uvigerina brunnensis.
U. proboscidea.
Chilostomella ovoidea.
Planulina wuellerstorfi.

The deposit contains almost exclusively Foraminiferal tests, mainly of pelagic species. A few small fragments of Echinoderm spines are the only other remains recognizable. The mud appears to contain a considerable amount of organic matter.

Station 53 : South Arabian Coast ; depth 13·5 metres ; coarse dredge sample only ; coarse calcareous sand.

Chief components.	Frequency.	% coarse material.
Foraminifera . .	R .	1·3
Crustacea . . .	F .	2·1
Calcareous gravel .	A .	64·2
Other mineral gravel .	A .	32·4
		100·0

Benthic remains :—

Foraminifera.

Quinqueloculina rupertiana.
Triloculina trigonula.
Elphidium craticulatum.
El. crispum.
Operculina granulosa.
Heterostegina depressa.
Amphistegina radiata.

Globigerina bulloides was the only pelagic species identified. The sand is mainly of organic origin, but much of the calcareous material is unidentifiable. Lumps of calcareous conglomerate and small stones encrusted with *Lithothamnion* and Serpulid tubes are common. Fragments of *Balanus amphitrite* and various Poriferan spicules, including some of *Hyalonema* type, are present.

Station 54 : South Arabian Coast ; depth 1046 metres ; Agassiz trawl sample ; stiff, green, clayey mud with few animal remains ; mud 82·1% ; organic remains 17·9%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Globigerina dubia.

Benthic remains :—

Foraminifera.

Textularia conica.
Clavulina pacifica.
Robulus limbosus.
Dentalina consobrina.
Nodosaria pyrula.
Frondicularia advena.
Lagena marginata.
Bulimina ovata.
B. pyrula.
Bulimina pyrula var. *spinescens.*
Virgulina subsquamosa.
Bolivina beyrichi var. *alata.*
Uvigerina brunnensis.
U. proboscidea.
U. pygmæa.
Siphogenerina virgula.
Sphæroidina bulloides.

The mud is not homogeneous, but contains hard, brittle masses bored by Mollusca. These pieces are not very clayey, but are calcareous, and appear to be consolidated about the borings. Fæcal pellets occur to a small extent in the unconsolidated mud. No siliceous remains were found.

Station 55 : South Arabian Coast ; depth 794 metres ; Salpa dredge and Bigelow samples ; dark brown-green diatomaceous mud.

This is a slightly calcareous sandy mud with much organic matter and very numerous diatom frustules, of the species *Coscinodiscus oculis-iridis* var. *borealis* (Bail.), Cl. A small amount of coarse material was obtained, and this consists of worn Foraminifera, mainly benthic forms, and pieces of calcareous rock formed of shell and Foraminiferan material, cemented together. Some fish-scales are present (see Pl. I, figs. 5, 6).

Station 56 : South Arabian Coast ; depth 421 metres ; coarse and entire dredge samples ; fine green mud ; mud 94·8% ; organic remains 5·2%.

Chief components.	Frequency.	% coarse material.	% deposit.
Polychæta	C	8·6	0·4
Polyzoa	R	1·6	0·1
Echinodermata	R	1·8	0·1
Crustacea	F	2·6	0·1
Lamellibranchiata	C	9·4	0·5
Gasteropoda	F	7·3	0·4
Pteropoda	C	7·8	0·4
Pisces	VC	10·7	0·5
Other remains	A	50·2	2·7
		100·0	5·2

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides sacculifera.
Globigerinella æquilateralis.
Orbulina universa.
Pulleniatina obliquiloculata.
Globorotalia menardii.

Pteropoda.

Creseis acicula.
Cr. virgula.
Hyalocylis striata.
Clio pyramidata.
Diacria quadridentata.
Cavolinia longirostris.
Atlanta sp.

Benthic remains :—

Foraminifera.

Operculina granulosa.
Bulimina pyrula.
B. subornata.
Virgulina squamosa.
Bolivina pygmæa.
Uvigerina tenuistriata.
Amphistegina radiata.

Sulphuretted hydrogen was present in this mud. Fish bones and scales are very abundant. Otoliths and sharks' teeth are present, but in fewer numbers. The same species of *Coscinodiscus*, *C. oculis iridis* var. *borealis*, is present at this station, but is less abundant than at the preceding.

Station 57 : South Arabian Coast ; depth 703 metres ; coarse dredge sample ; soft green mud ; mud 93·2% ; organic remains 6·8%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Orbulina universa.
Globorotalia canariensis.
Gl. menardii.

Pteropoda.

Creseis acicula.
Cr. virgula.
Diacria quadridentata.
Cavolinia longirostris.
Atlanta sp.

Benthic remains :—

Foraminifera.

Nonionella sp.
Bulimina ovata.
B. pyrula.
Bolivina beyrichi.
B. pygmæa.
Uvigerina pygmæa.
Uvigerina tenuistriata.
? *Siphogenerina dimorpha.*
Valvulineria allomorphinoides.
Cancris auriculus.
Ehrenbergina pacifica.

Some sulphuretted hydrogen was present in the mud, but less than at Sta. 56. There are no diatoms here, and animal remains are rare. The chief components are fish-bones, scales and otoliths. Rare Crustacean and Echinoderm remains occur. There is some limestone on the bottom.

Station 58 : South Arabian Coast ; depth 1189–1354 metres ; dredge sample ; calcareous rock and limestone.

The deposit here is recorded in the " Station List " as green mud, but no sample is preserved beyond the rock fragments. The calcareous rock is very soft and contains numerous shell-fragments and benthic Foraminifera. A few pieces show *Globigerina* spp., *Orbulina universa* and *Globorotalia menardii*. Rotaliidæ, Otoliths and Echinoderm remains are readily recognizable in this soft calcareous conglomerate.

Station 59 : South Arabian Coast ; depth 1948 metres ; Bigelow sample ; light brown calcareous mud ; mud 86·0% ; organic remains 14·0%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides rubra.
Orbulina universa.
Pulleniatina obliquiloculata.
Globorotalia menardii.

Benthic remains :—

Foraminifera.

Clavulina communis.
Bulimina ovata.
Laticarinina pauperata.

Foraminifera are the only organic calcareous remains present in this deposit. A few monaxon and triaxon sponge spicules were the only siliceous remains found. Organic matter is abundant.

Station 60 : Northern Arabian Sea ; depth 3054 metres ; small Bigelow sample ;

grey-brown, highly calcareous mud with a considerable number of intact Foraminifera ; mud 82·3% ; organic remains 17·7%.

Pelagic remains (see Pl. II, fig. 5) :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides conglobata.
Gl. rubra.
Globigerinoides sacculifera.
Orbulina universa.
Pulleniatina obliquiloculata.
Globorotalia menardii.

This deposit resembles a Globigerina ooze to some extent, but contains a considerable amount of material insoluble in hydrochloric acid and apparently of a clay nature. Unlike similar oozes bordering on Red clay, this material is not red-brown, like red clay, but is a dirty brownish-grey colour. The non-calcareous part of this deposit is thus probably intermediate in composition between red and grey clay.

Station 62 : Northern Arabian Sea ; depth 1893 metres ; small Bigelow sample ; grey calcareous, clayey deposit, impure Globigerina ooze ; mud 87·5% ; organic remains 12·5%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides conglobata.
Gl. rubra.
Globigerinoides sacculifera.
Pulleniatina obliquiloculata.
Globorotalia menardii.

Benthic remains :—

Foraminifera.

Pyrgo serrata.
Bulimina aculeata.

This deposit is very similar to that from the preceding station, but there are fewer Foraminifera.

Station 63 : Northern Arabian Sea ; depth 1703 metres ; small Bigelow sample ; grey-green, calcareous, clayey deposit with very few Foraminifera ; mud 94·4% ; organic remains 5·6%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Globigerinoides rubra.
Globorotalia menardii.

This deposit is a pure grey clay. The only benthic Foraminiferan found was a species of *Bulimina*. There are no siliceous remains. The insoluble material is green-grey.

Station 64 : Gulf of Oman ; depth 448 metres ; small Bigelow sample ; grey clay ; mud 94·9% ; organic remains 5·1%.

There are exceedingly few animal remains in this deposit. The following three species of Foraminifera were identified :—

Globigerina bulloides.
Bulimina ovata.
Uvigerina pygmæa.

One fish vertebra was found. There are no siliceous organisms. The insoluble residue is grey-green as at the last station.

Station 65 : Gulf of Oman ; depth 907 metres ; small Bigelow sample ; green, slightly calcareous mud ; mud 96·6% ; organic remains 3·5%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Pulleniatina obliquiloculata.
Globorotalia canariensis.
Gl. menardii.

Benthic remains :—

Foraminifera.

Textularia agglutinans.
Verneulina scabra.
Pyrgo murrhina.
Nonion umbilicatulum.
Bulimina ovata.
B. pyrula.
B. subornata.
Virgulina subsquamosa.
Uvigerina pygmæa.
U. schwageri.
Cancris auriculus.
Planulina arimensis.
Pl. wuellerstorfi.
Laticarinina pauperata.

The only other remains present are a few vertebræ, scales and otoliths of fish.

Station 66 : Gulf of Oman ; depth 609 metres ; small Bigelow sample ; green, calcareous mud ; mud 94·6% ; organic remains 5·4%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides rubra.
Globorotalia menardii.

Benthic remains :—

Foraminifera.

Textularia sagittula.
Sigmoilina schlumbergeri.
Robulus calcar.
Bulimina ovata.
Bolivina beyrichi.
Uvigerina pygmæa.
Uvigerina tenuistriata.
Valvulineria allomorphinoides.
Cancris auriculus.
Ehrenbergina pacifica.
Cibicides lobatulus.

Foraminifera are not very common in this deposit. Other remains are absent. There are no siliceous organisms.

Station 67 : Gulf of Oman ; depth 274 metres ; coarse and intact dredge samples ; green mud with Pteropod shells, limestone pebbles and igneous rock ; mud 96·0% ; organic remains 4·0%.

Chief components.	Frequency.	% coarse material.	% deposit.
Pteropoda . . .	A .	78·0 .	3·1
Other remains . . .	R .	22·0 .	0·9
		100·0	4·0

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Orbulina universa.
Pulleniatina obliquiloculata.

Pteropoda.

Limacina inflata. *Diacria quadridentata.*
Creseis acicula. *Cavolinia longirostris.*
Cr. virgula. *Atlanta* sp.
Hyalocylis striata.

Benthic remains :—

Foraminifera.

Textularia sp. *Nodosaria pyrula.*
Clavulina angularis. *Saracenaria italica.*
Cl. pacifica. *Bulimina pyrula.*
Spiroloculina sp. *Uvigerina pygmæa.*
Triloculina sp. *Rotalia margaritifera.*
Nodosaria pauciloculata. *Cancris auriculus.*

Mollusca.

Argonauta sp. *Rostellaria* sp.

In addition to the above, other Mollusc, Echinoderm, coral and Crustacean remains occur sparingly. A few fish otoliths and bones are present. The mud contains large numbers of small fæcal pellets.

Station 70 : Gulf of Oman ; depth 196 metres ; small Bigelow sample ; grey-green mud ; mud 86·8% ; organic remains 13·2%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides. *Globigerinoides rubra.*

Pteropoda.

Creseis sp.

Benthic remains :—

Foraminifera.

Clavulina angularis. *Rotalia calcar.*
Lagena sp. *Cancris auriculus.*
Bolivina dilatata. *Ehrenbergina pacifica.*

No siliceous organisms were observed.

Station 72 : Gulf of Oman ; depth 73 metres ; coarse Agassiz trawl sample and mud from Lamellibranch shells ; calcareous conglomerate, shells and shell gravel ; mud from bivalves gave : mud 84·6% ; organic remains 15·4%.

Chief components.	Frequency.	% coarse material.	% deposit.
Foraminifera . . .	F	1·6	0·3
Polychæta . . .	F	2·5	0·4
Crustacea	VC	10·1	1·5
(*Balanus*)	(F)	(3·5)	(0·6)
Lamellibranchiata . .	A	58·5	9·0
Gasteropoda . . .	C	13·0	2·0
Pteropoda	F	2·6	0·4
Other remains . . .	F	11·7	1·8
		100·0	15·4

Benthic remains :—

Foraminifera.

Reophax sp.
Textularia agglutinans.
T. gramen.
T. porrecta.
Quinqueloculina sp.
Spiroloculina grateloupi var. *acescata.*
Triloculina tricarinata.
Lenticulina rotulata.
Nonion grateloupi.
Nonion scaphum.
? *Nonionella auris.*
Elphidium ? *articulatum.*
El. craticulatum.
Eponides præcinctus.
Rotalia calcar.
R. margaritifera.
R. papillosa.
Miniacina miniacea.

It is possible that the mud contained in the bivalves is not representative of the deposit, as the shells may have been filled by the finer components of the sediment being drifted into them. The Gasteropoda are almost entirely of one species of *Turritella*. A few small solitary corals occur on some of these shells. Abundant fragments of shells and worm-tubes are visible in the calcareous conglomerate. Fragments of encrusting Polyzoa and *Balanus* spp. occur in the sand and gravel, evidently derived from these organisms growing on the conglomerate rock.

Station 73 : Gulf of Oman ; depth 91 metres ; coarse and intact Priestman grab samples ; very sandy, green mud with Molluscan remains ; mud 35·5% ; organic remains 64·5% (These values are only approximate, as much of the finer material consists of finely triturated shell fragments.)

Chief components.	Frequency.	% coarse material.	% deposit.
Foraminifera	F	1·9	1·2
Polychæta	F	3·9	2·5
Echinodermata	F	2·1	1·4
Crustacea	VC	10·1	6·5
(*Balanus*)	(C)	(6·6)	(4·3)
Lamellibranchiata	A	46·5	30·0
Gasteropoda	C	12·1	7·8
Pteropoda	F	2·4	1·5
Scaphopoda	R	0·1	0·1
Other remains	C	20·9	13·5
		100·0	64·5

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides sacculifera.
Globigerinella æquilateralis.
Orbulina universa.
Globorotalia menardii.

Pteropoda.

Limacina inflata.
Creseis acicula.
Cr. virgula.
Hyalocylis striata.
Cavolinia longirostris.
Atlanta sp.

Benthic remains :—

Foraminifera.

Reophax sp.
Textularia agglutinans.
T. conica.
T. semialata.
Quinqueloculina sp.
Massilina arenaria.
Spiroloculina depressa.
Triloculina tricarinata.
Robulus gibbus.
Bolivina beyrichi var. *alata.*
Eponides præcinctus.
Rotalia margaritifera.
R. papillosa.

Rare fragments of Polyzoa and solitary corals, Alcyonarian spicules and Ostracod valves occur.

Station 74 : Gulf of Oman ; depth 155 metres ; coarse Priestman grab sample ; probably sandy green mud as at the previous two stations.

Chief components.	Frequency.	% coarse material.
Foraminifera	F	4·4
Corals	R	2·7
Polychæta	VC	10·6
Polyzoa	F	3·0
Echinodermata	F	5·5
Crustacea	VC	9·6
Lamellibranchiata	C	15·5
Gasteropoda	VC	25·3
Pteropoda	C	8·0
Scaphopoda	F	3·3
Pisces	F	5·5
Other remains	F	6·6
		100·0

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Globigerinoides sacculifera.
Globigerinella æquilateralis.
Orbulina universa.
Pulleniatina obliquiloculata.

Pteropoda.

Limacina inflata.
Creseis acicula.
Cr. virgula.
Diacria quadridentata.
Cavolinia longirostris.
C. uncinata.
Atlanta sp.

Benthic remains :—

Foraminifera.

Quinqueloculina sp.
Spiroloculina depressa.
Triloculina tricarinata.
Pyrgo depressa.
Robulus sp.
Nodosaria vertebralis.
Virgulina sp.
Bolivina sp.
Eponides præcinctus.
Rotalia margaritifera.
R. papillosa.
Miniacina miniacea.

Polychæt tubes and Gasteropoda are much commoner here than at the two previous stations, but bivalve remains are fewer. Ostracod valves, fish vertebræ and Alcyonarian spicules are present (see Pl. I, fig. 2).

Station 75 : Gulf of Oman ; depth 201 metres ; Priestman grab samples ; impure Pteropod ooze ; mud 61·0% ; organic remains 39·0%.

Chief components.	Frequency.	% coarse material.	% deposit.
Polychæta	C	5·2	2·0
Polyzoa	F	3·8	1·5
Echinodermata	C	7·5	3·0
Crustacea	C	7·0	2·7
Lamellibranchiata	R	4·4	1·7
Gasteropoda	VC	24·9	9·7
Pteropoda	A	28·7	11·2
(*Creseis*)	(A)	(15·8)	(6·2)
Scaphopoda	C	6·6	2·6
Pisces	F	4·4	1·7
Other remains	C	7·5	2·9
		100·0	39·0

Pelagic remains :—

Foraminifera.

Globigerina bulloides. *Globorotalia menardii.*

Pteropoda.

Creseis acicula. *Diacria quadridentata.*

Hyalocylis striata. *Cavolinia longirostris.*

This Pteropod ooze consists largely of the straight-shelled species, *Creseis acicula* (see Pl. III, fig. 2). Both pelagic and neritic Foraminifera are scarce. Pieces of Brachyuran carapaces and Stomatopod chelæ are recognizable among the crustacean remains. A few fish vertebræ and a shark's tooth were found.

Station 76 : Gulf of Oman ; depth 3289 metres ; small Bigelow sample ; grey calcareous mud ; mud 95·2% ; organic remains 4·8%.

This deposit contains very few organic remains. No siliceous organisms or Foraminifera were found nor shell fragments. One Ostracod valve was the only animal fragment recovered. A few cinder particles, quartz grains and other mineral grains occur.

Station 77 : South Arabian Coast ; depth 411 metres ; coarse Priestman grab sample only ; green Pteropod mud, smelling strongly of hydrogen sulphide ; only washed material from this station was preserved.

Chief components.	Frequency.	% coarse material.
Polychæta	F	2·3
Crustacea	F	3·4
Lamellibranchiata	F	17·1
Gasteropoda	F	
Pteropoda	A	22·5
Pisces	A	28·3
Other remains	A	26·4
		100·0

Pelagic remains :—

Foraminifera.

Orbulina universa. *Globorotalia menardii.*
Pulleniatina obliquiloculata.

Pteropoda.

Peraclis reticulata. *Clio pyramidata.*
Creseis acicula. *Diacria quadridentata.*
Cr. virgula. *Cavolinia longirostris.*
Hyalocylis striata. *Atlanta* sp.

The commonest animal remains are bones and scales of fish. Otoliths, however, are not common. Mollusca, other than Pteropoda, are rare. The "other remains" consist largely of unseparated mud particles and carbonaceous granules, which are rather common. The only benthic Foraminifera identified were *Robulus gibbus* and *Eponides præcinctus.*

Station 79 : South Arabian Coast ; depth 102 metres ; small Bigelow sample ; friable green mud, smelling of hydrogen sulphide ; mud 94·0% ; organic remains 6·0%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides. *Globigerinoides rubra.*
Globigerinoides conglobata. *Globorotalia menardii.*

Organic remains are rare in this sediment. Benthic Foraminifera are represented by *Robulus* sp., which is fairly common, and by rare specimens of *Uvigerina pygmæa.* Molluscan remains are rare. A few fish bones are present. Siliceous organisms are represented by fragmentary sponge spicules and a few *Coscinodiscus* sp.

Station 80 : South Arabian Coast ; depth 16–22 metres ; debris material only ; coarse sand and shell.

Only a small amount of sand and a few large fragments are preserved. Shells of *Terebra, Conus* and *Dentalium* occur. The sand is in part siliceous and part calcareous. The usual shallow-water organisms are present. *Elphidium* sp., *Planulina* sp., *Rotalia* sp. and *Quinqueloculina* sp. were the only Foraminifera identified. A few solitary corals are present.

Station 81 : Northern Arabian Sea ; depth 3351 metres ; Bigelow and coarse net sample ; grey calcareous mud ; mud 95·0% ; organic remains 5·0%.

Pelagic remains are represented by three species of Foraminifera, *Globigerina bulloides, G. dubia,* and *Globigerinoides conglobata,* and two of Pteropoda, *Diacria quadridentata* and *Cavolinia longirostris.* Molluscan remains are the commonest organic remains in the deposit. Echinoderm fragments and fish remains also occur. A few *Coscinodiscus* sp. are the only siliceous remains identified. Animal remains are rather rare in this deposit, but small carbonaceous particles, presumably cinders, are rather common.

Station 85 : Northern Arabian Sea ; depth 1687 metres ; small Bigelow sample ; grey calcareous mud ; mud 91·6% ; organic remains 8·4%.

Pelagic remains :—

Foraminifera :

Globigerina bulloides. *Orbulina universa.*
Gl. dubia. *Pulleniatina obliquiloculata.*
Globigerinoides rubra. *Globorotalia menardii.*
Gl. sacculifera.

Pteropoda.

Limacina inflata. *Atlanta* sp.

Very few benthic remains are present in this deposit (see Pl. I, fig. 1) ; *Pyrgo depressa* and *Cibicides lobatulus* are the only Foraminifera identified. No Molluscan or Echinoderm remains were found, and the only other materials of organic origin are a few otoliths and very rare fragments of Poriferan spicules.

Station 87 : Northern Arabian Sea ; depth 582 metres ; small Bigelow sample ; grey, gritty, calcareous mud with numerous Foraminifera ; mud 55·2% ; organic remains 44·8%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides. *Globigerinella digitata.*
Gl. dubia. *Orbulina universa.*
Globigerinoides conglobata. *Pulleniatina obliquiloculata.*
Gl. rubra. *Sphæroidinella dehiscens.*
Gl. sacculifera. *Globorotalia menardii.*
Globigerinella æquilateralis.

Pteropoda.

Creseis sp.

Benthic remains are represented by Lamellibranch fragments and the following four Foraminifera :—

Dentalina filiformis. *Cancris auriculus.*
Bolivina dilatata. *Ehrenbergina serrata.*

No siliceous remains were found in this material. A considerable amount of organic matter appears to be present. The deposit is a rather impure Globigerina ooze.

Station 88 : Northern Arabian Sea ; depth 274 metres ; Priestman grab samples ; light grey, calcareous clay, smelling faintly of H_2S when fresh, with a thin superficial layer of dark brown mud ; mud 87·3% ; total organic remains 12·7% ; coarse organic remains 1·9%.

Chief components.	Frequency.	% coarse material.	% deposit.
Lamellibranchiata . .	VC .	25·4 .	0·5
Gasteropoda . . .	F .	10·1 .	0·2
Pteropoda . . .	A .	33·3 .	0·6
Pisces	C .	6·3 .	0·1
Other groups . . .	F .	7·8 .	0·2
Calcareous residue . .	F .	17·1 .	0·3
		100·0	1·9

Pelagic remains :—

Foraminifera.

Globigerina bulloides. *Globigerinoides rubra.*

Pteropoda.

Creseis acicula. *Cavolinia longirostris.*
Cr. virgula. *C. uncinata.*
Hyalocylis striata. *Atlanta* sp.
Diacria quadridentata.

Benthic remains :—

Foraminifera.

Robulus acutauricularis. *Bulimina pyrula.*
Bulimina elongata. *Uvigerina bifurcata.*
B. ovata. *U. pygmœa.*

A considerable part of the animal remains consists of very fine, white calcareous particles, presumably of Molluscan origin, but too small for identification. In calculating the percentage of the deposit contributed by the different phyla this fine material has been ignored. The final column (% deposit) in the above table has been calculated on the coarse animal remains only.

Station 89 : Northern Arabian Sea ; depth 193 metres ; coarse Priestman grab sample ; no intact material ; sand, shell and rock.

Chief components.	Frequency.	% coarse material.
Foraminifera	R	0·1
Polychæta	R	0·4
Echinodermata	R	0·9
Crustacea	R	0·2
Lamellibranchiata	C	15·1
Gasteropoda	C	12·7
Pteropoda	R	1·9
Pisces	R	0·2
Other remains	A	68·5
		100·0

Pelagic remains :

Pteropoda.

Limacina inflata. *Diacria quadridentata.*
Creseis acicula. *Cavolinia longirostris.*
Cr. virgula. *C. uncinata.*
Hyalocylis striata. *Atlanta* sp.

No pelagic Foraminifera were identified. *Operculina granulosa* and *Heterostegina operculinoides* were the only benthic species identified. The coarse material at this station consists of calcareous rubble, most of which is unidentifiable ; some appears to be derived from large shells, a few fragments of which occur ; most of the Molluscan material consists of small shells and shell-fragments. Foraminifera are notable by their absence; only a very few worn specimens are present in the material.

Station 92 : Central Arabian Sea ; depth 3722 metres ; Bigelow sample ; creamy Globigerina ooze, light brown when wet ; mud 85·9% ; organic remains 14·1%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides rubra.
Globigerinoides sacculifera.
Pulleniatina obliquiloculata.
Globorotalia menardii.

This is a nearly pure Globigerina ooze. There are very few intact tests of Foraminifera present, and benthic forms are absent. A few Coccoliths are present and also a few fragments of *Coscinodiscus* sp.

Station 93 : Central Arabian Sea ; depth 3991 metres ; Bigelow sample ; transitional Globigerina ooze-red clay ; mud 90·4% ; organic remains 9·6%.

Pelagic remains :—

Foraminifera :

Globigerina bulloides.
Gl. dubia.
Globigerinoides conglobata.
Pulleniatina obliquiloculata.
Globorotalia menardii.

No other organic remains, calcareous or siliceous, are present. Very few of the Foraminifera are intact.

Station 100 : Central Arabian Sea ; depth 4082 metres ; Bigelow sample ; red clay.

The red clay forms almost 100% of this deposit. No Foraminifera were sifted out, and there is a very low calcium carbonate content. Siliceous remains present include various kinds of Poriferan spicules and diatom frustules including *Coscinodiscus* sp., mainly in a fragmentary condition. No Radiolaria are present.

Station 101 : Central Arabian Sea ; depth 5285 metres ; Bigelow sample ; red clay.

This deposit is very similar to that from the preceding station. No calcareous remains were found, and the same siliceous organisms as at Sta. 100 are present.

Station 102 : Central Arabian Sea ; depth 3215 metres ; Bigelow sample ; Globigerina ooze ; mud 79·3% ; organic remains 20·7%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides conglobata.
Gl. rubra.
Gl. sacculifera.
Orbulina universa.
Pulleniatina obliquiloculata.
Globorotalia menardii.
Gl. tumida.

No Pteropoda are present, and no benthic Foraminifera. The only benthic remains found were a few Poriferan spicules. *Coscinodiscus* frustules are again present, as at the last two stations, and also a few Radiolarian skeletons.

This Globigerina ooze is impure, containing some red clay, but the remains of pelagic Foraminifera are very common, so that the clay only imparts a faint creamy colour to the deposit. The apparently complete absence of benthic Foraminifera is noteworthy as these tests are often common in Globigerina ooze.

Station 103 : Zanzibar area ; depth 101 metres ; Priestman grab samples ; grey-green, incoherent, gritty mud with much siliceous sand and gravel ; mud 74·6% ; sand and gravel 11·3% ; organic remains 14·1%.

Chief components.	Frequency.	% coarse material.	% deposit.
Foraminifera	A	6·9	1·8
Corals	R	2·6	0·7
Polychæta	R	0·5	0·1
Polyzoa	VC	6·8	1·7
Echinodermata	F	3·9	1·0
Crustacea	F	4·3	1·1
Lamellibranchiata	VC	19·8	5·0
Gasteropoda	F	7·2	1·8
Pteropoda	R	1·8	0·5
Scaphopoda	R	0·7	0·2
Pisces	R	0·4	0·1
Other remains	A	45·1	11·4
		100·0	25·4

The " Other remains " in the above list include unidentifiable calcareous grains and carbonaceous particles as well as quartz grains (see Pl. II, fig. 3).

Pelagic remains :—

Pteropoda.

Creseis acicula.
Cr. virgula.
Clio pyramidata.
Diacria quadridentata.
Cavolinia globulosa.
C. longirostris.
Atlanta sp.

No pelagic Foraminifera were found.

Benthic remains :—

Foraminifera.

Textularia agglutinans.
T. corrugata.
T. sagittula var. *atrata.*
T. tuberosa.
Sigmoilina schlumbergeri.
Triloculina tricarinata.
Pyrgo sarsi.
Placopsilina cenomana.
Robulus convergens.
R. costatus var. *multicostatus.*
R. orbicularis.
Nodosaria flinti.
N. subscalaris.
Vaginulina legumen.
Nonion ? asterizans.
Nonion scaphum.
Elphidium craticulatum.
El. crispum.
Operculina granulosa.
Heterostegina operculinoides.
Sorites marginalis.
Uvigerina tenuistriata.
Rotalia papillosa.
Amphistegina radiata.
Cibicides lobatulus.
Planorbulinella larvata.
Carpenteria monticularis.
C. proteiformis.
Miniacina miniacea.

Corals.

Diaseris sp.

The majority of the animal remains have been pulverized into small fragments, perhaps owing to their being rolled about along with the quartz grains. Many of the Foraminifera, particularly specimens of *Operculina granulosa*, are discoloured and blackened. Presumably all these specimens were dead before being collected, and had become affected by contact with the mud. On dissolving out the calcium carbonate of the test with acid, green casts are left. The dark colour is apparently due to this contained material (? glauconite), as no sulphide of iron appears to be present.

The greenish colour of the mud is in part due to contained organic matter, some of which was dissolved out by the alcohol used to preserve the sample of the deposit. Some of the colour is due to the presence of the green mineral material in the deposit.

Station 104: Zanzibar Area; depth 207 metres; Priestman grab samples; grey-green mud similar to that from Sta. 103, but finer and more coherent; mud 75·7%; sand and gravel 16·6%; organic remains 7·7%.

Chief components.	Frequency.	% coarse material.	% deposit.
Foraminifera	C	1·4	0·4
Corals	F	6·2	1·5
Polychæta	F	3·6	0·9
Polyzoa	R	0·7	0·2
Echinodermata	F	5·0	1·2
Crustacea	R	0·5	0·1
Lamellibranchiata	R	3·6	0·9
Gasteropoda	R	5·8	1·4
Pteropoda	F	4·6	1·1
Scaphopoda	R	0·1	tr.
Pisces	R	0·1	tr.
Other remains	C	68·4	16·6
		100·0	24·3

Pelagic remains :—

Pteropoda.

Creseis acicula.
Cr. virgula.
Cavolinia longirostris.

No pelagic Foraminifera were identified.

Benthic remains :—

Foraminifera.

Textularia sagittula.
Spiroloculina depressa.
Sigmoilina schlumbergeri.
Pyrgo comata.
P. depressa.
P. vespertilio.
Robulus costatus var. multicostatus.
R. iota.
Robulus orbicularis.
Lenticulina rotulata.
Marginulina glabra.
Nodosaria flinti.
Frondicularia plicata.
Operculina granulosa.
Amphistegina radiata.
Cibicides lobatulus.

Cirripedia.

Verruca sp.
Balanus sp.

Station 105 : Zanzibar Area ; depth 280 metres ; Agassiz trawl sample ; clayey grey mud with very few animal remains ; mud 98·1% ; sand 0·4% ; organic remains 1·5%.

Chief components.	Frequency.	% coarse material.	% deposit.
Foraminifera	C	19·3	0·4
Corals	R	1·8	tr.
Polychæta	R	0·4	tr.
Polyzoa	R	0·9	tr.
Echinodermata	F	5·0	0·1
Crustacea	R	0·6	tr.
Lamellibranchiata	F	5·9	0·1
Gasteropoda	F	11·3	0·2
Pteropoda	VC	15·1	0·3
Pisces	F	3·6	0·1
Other remains	F	36·1	0·7
		100·0	1·9

No pelagic Foraminifera were found in this deposit.

Benthic remains :—

Foraminifera.

Storthosphæra albida.
Pilulina jeffreysi.
Tholosina bulla.
Dendrophrya ramosa.
Aschemonella sp.
Ammodiscoides turbinatus.
Tolypammina vagans.
Ammolagena clavata.
Haplophragmoides subglobosum.
Textularia gramen.
Valvulina conica.
V. fusca.
Clavulina communis.
Cl. parisiensis.
Pyrgo depressa.
Biloculinella globula.
Robulus costatus.
R. costatus var. *multicostatus.*
R. echinatus.
R. iota.
Lenticulina rotulata.
Nodosaria soluta.
Saracenaria italica.
Operculina granulosa.
Bulimina ovata.
Rotalia papillosa.
Epistomina elegans.

A few valves of *Balanus* sp. occur in this material and a considerable number of specimens of *Cavolinia longirostris*. This Pteropod is the only pelagic organism found in the deposit. Fragments of coal, cinders and decayed pieces of timber cored by *Teredo* sp. are frequent. The large arenaceous Foraminiferan, *Dendrophrya ramosa* Cushman, is very abundant, and forms the bulk of the material left after washing out the mud (see Pl. IV, fig. 1).

Station 106 : Zanzibar Area ; depth 212 metres ; Bigelow sample ; grey-green calcareous mud ; mud 90·1% ; organic remains 9·9%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides. *Globigerinoides rubra.*
Gl. dubia. *Orbulina universa.*

Pteropoda.

Limacina inflata. *Atlanta* sp.
Creseis virgula.

Benthic remains are not very abundant. Molluscan and Echinoderm remains are only rare or frequent and only two benthic Foraminifera were identified, namely, *Pilulina jeffreysi* and *Triloculina* sp. A few sponge spicules were the only siliceous remains found.

Station 108 : Zanzibar Area ; depth 781 metres ; Bigelow sample ; brown-grey calcareous mud ; mud 96·2% ; organic remains 3·8%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides. *Orbulina universa.*
Gl. dubia. *Pulleniatina obliquiloculata.*
Globigerinoides rubra. *Globorotalia menardii.*
Gl. sacculifera.

Benthic remains are very rare at this station. A few gasteropod fragments and Ostracod valves occur. Only two benthic Foraminifera, *Quinqueloculina* sp. and *Triloculina* sp., were found. Poriferan spicule fragments were the only siliceous remains seen.

Station 109 : Zanzibar Area ; depth 640 metres ; Agassiz trawl debris ; light grey mud.

No proper sample of the deposit at this station was preserved. The following organisms were found in debris :

Pteropoda.

Clio pyramidata. *Diacria trispinosa.*
Cuvierina columnella.

Foraminifera.

Rhabdammina abyssorum. *Amphisorus hemprichi.*
Pyrgo sp.

In addition, fragments of Lamellibranchiata, Gasteropoda, Scaphopoda and Echinodermata, particularly spines, occurred. Many of the Echinoderm spines had specimens of the Cirripede *Heteralepas typica* Nilsson-Cantell attached to them.

Station 110 : Zanzibar Area ; depth 329 metres ; Bigelow sample and materials from Otter trawl ; transitional from brown mud to Globigerina ooze ; an impure Globigerina ooze ; mud 37·9% ; organic remains 62·1%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides. *Orbulina universa.*
Gl. dubia. *Pulleniatina obliquiloculata.*
Globigerinoides sacculifera. *Globorotalia menardii.*

Pteropoda.

Limacina inflata, *Cavolinia* sp.
Creseis sp. *Atlanta* sp.

Benthic remains :—

Molluscan remains are rare, but fragments of *Verruca* sp. are common and Ostracod valves frequent. Some cinders are present and one piece of pumice was preserved, but the chief benthic remains are Foraminifera, which are abundant both in numbers and species. A list follows :

Reophax agglutinans.
R. bilocularis.
R. guttifer.
Ammodiscus incertus.
Tolypammina vagans.
Ammolagena clavata.
Haplophragmoides sp.
Ammobaculites calcareum.
Spiroplectammina milletti.
Textularia conica.
T. sagittula var. *fistulosa.*
Clavulina communis.
Sigmoilina schlumbergeri.
Pyrgo denticulata.
P. depressa.
P. murrhina.
Cornuspira carinata.
Planispirina sphaera.
Trochammina squamata.
Robulus costatus.
R. iota.
Lenticulina rotulata.
Planularia tricarinella.
Vaginulina linearis.
Nonion pacificum.
N. pompilioides.
Bulimina ovata.
B. pyrula.
Uvigerina aculeata.
U. brunnensis.
Siphogenerina striata var. *curta.*
Angulogerina carinata.
Gyroidina soldani.
Rotalia papillosa.
Epistomina elegans.
Cancris auriculus.
Anomalina balthica.
Planulina ariminensis.
Pl. wuellerstorfi.
Cibicides lobatulus.
Carpenteria monticularis.
C. proteiformis.

Station 111 : Zanzibar Area ; depth 73–165 metres ; no intact sample.

The bottom would appear to be composed largely of calcareous rubble or conglomerate formed of fragments of shells and other neritic animals, cemented with fine calcareous material and overgrown with attached Polyzoa, *Lithothamnion*, etc. Dead *Balani* and their valves are of frequent occurrence. Attached Foraminifera and Polychæt tubes are common. The following Foraminifera were found in a small spirit-preserved sample of sand.

Pelagic :—

Globigerina bulloides.
Globigerina dubia.

Benthic :—

Spiroloculina depressa.
Triloculina sp.
Placopsilina cenomana.
Robulus sp.
Heterostegina sp.
Alveolinella boscii.
Amphistegina radiata.
Planorbulinella larvata.
Carpenteria monticularis.
C. proteiformis.
C. utricularis.
Sporadotrema cylindricum.
C. mesentericum.
Miniacina miniacea.

Alcyonarian spicules and *Stenohelia* fragments are present in the fine sand preserved with the conglomerate.

Station 112 : Zanzibar Area ; depth 113 metres ; coarse material from Priestman grab only ; shallow-water sand of quartz grains and organic calcareous structures.

The material contains fragments of the usual shallow-water fauna, including many Foraminifera. Pelagic organisms are represented by *Globigerinoides rubra* and two Pteropods, *Diacria trispinosa* and *Cavolinia longirostris*, only. Among benthic organisms, fragments of the Polyzoan *Haswellia* and a Gasteropod, probably *Vermetus* sp., occur. The following Foraminifera were identified :—

Textularia agglutinans.
Gaudryina rugulosa.
Quinqueloculina sp.
Spiroloculina depressa.
Triloculina tricarinata.
Pyrgo murrhina.
Robulus orbicularis.
Robulus sp.
Nodosaria scalaris.
Elphidium crispum.
Heterostegina operculinoides.
Amphisorus hemprichi.
Alveolinella boscii.
Sphæridia papillata.
Amphistegina radiata.
Planorbulinella larvata.
Sporadotrema cylindricum.
Sp. mesentericum.
Miniacina miniacea.

Station 113 : Zanzibar Area ; depth 220 metres ; Priestman grab samples ; grey-brown muddy sand ; mud 53·9% ; mineral grains 38·0% ; organic remains 8·1%.

Chief components.	Frequency.	% coarse material.	% deposit.
Foraminifera	F	0·6	0·3
Alcyonaria	F	0·6	0·3
Corals	R	0·4	0·2
Polychæta	R	0·3	0·1
Polyzoa	R	0·6	0·3
Echinodermata	F	2·0	0·9
Crustacea	F	3·7	1·7
Lamellibranchiata	R	3·5	1·6
Gasteropoda	R	4·5	2·1
Pteropoda	R	0·7	0·4
Scaphopoda	R	0·3	0·1
Pisces	R	0·3	0·1
Other remains	A	82·5	38·0
		100·0	46·1

The " Other remains " consist for the most part of quartz grains and some unidentifiable calcareous material.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Orbulina universa.
Globorotalia menardii.

Pteropoda.

Limacina inflata.
Creseis acicula.
Creseis virgula.

Benthic remains :—

Foraminifera.

Textularia gramen.
T. trochus.
Gaudryina rugulosa.
Spiroloculina depressa.
Sigmoilina schlumbergeri.
Triloculina tricarinata.
Pyrgo vespertilio.
Nubecularia tuberosa.
Robulus sp.
Vaginulina linearis.
Nonion umbilicatulum.
Operculina granulosa.
Heterostegina suborbicularis.
Sorites marginalis.
Marginopora vertebralis.
Uvigerina aculeata.
Epistomina elegans.
Amphistegina radiata.
Planorbulinella larvata.
Gypsina vesicularis.
Carpenteria monticularis.

The calcareous remains are much broken and worn, due to grinding against the quartz grains, which are abundant here as at Sta. 103. A number of fragments of Cirripedia are recognizable among the crustacean remains, notably compartments and valves of *Balanus* and *Verruca*. A carina of *Lepas* sp. was found (see Pl. II, fig. 4).

Station 114 : Zanzibar Area ; depth 353 metres ; Priestman grab sample ; impure Globigerina ooze, transitional to brown terrigenous mud ; mud 31·6% ; organic remains 68·4%.

The organic remains in this deposit are almost entirely Foraminifera. No large Molluscan remains occur, the only Mollusca being small larval Gasteropoda no bigger than Globigerinæ.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides rubra.
Gl. sacculifera.
Orbulina universa.
Pulleniatina obliquiloculata.
Globorotalia menardii.
Gl. tumida.

Pteropoda.

Limacina inflata.
Creseis sp.
Atlanta sp.

Benthic remains :—

Foraminifera.

Spiroplectammina milletti.
Textularia flinti.
T. gramen.
T. sagittula.
Gaudryina baccata.
Clavulina communis.
Spiroloculina ? tenuis.
Sigmoilina schlumbergeri.
Triloculina sp.
Pyrgo denticulata.
P. depressa.
Cornuspira carinata.
Planispirina sphæra.
Robulus convergens.
R. subaculeatus.
Marginulina glabra.

Nodosaria hirsuta.
Vaginulina legumen.
Bulimina ovata.
B. pyrula.
Virgulina subsquamosa.
Uvigerina aculeata.
U. tenuistriata.
Siphogenerina striata var. *curta.*
Epistomina elegans.
Cancris auriculus.
Cymbaloporetta squamosa.
Chilostomella ovoidea.
Planulina ariminensis.
Pl. wuellerstorfi.
Cibicides lobatulus.

Poriferan spicules are frequent in this deposit. Ostracod valves occur.

Station 115 : Zanzibar Area ; depth 640 metres ; a small tube of debris is the only material.

The debris contained much unidentifiable material and mucoid matter, and yielded very few animal remains. The following Foraminifera were identified :

Globigerina bulloides.
Gl. dubia.
Globorotalia menardii.
Ammodiscus sp.

Spines and fragments of Echinodermata were the only other remains present.

Station 117 : Zanzibar Area ; depth 889 metres ; Bigelow sample ; light brown calcareous mud or impure Globigerina ooze ; mud 87·6% ; organic remains 12·4%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides conglobata.
Gl. sacculifera.
Orbulina universa.
Pulleniatina obliquiloculata.
Globorotalia menardii.
Gl. tumida.

Pteropoda.

Creseis sp.

Pteropoda are only represented by a few small fragments of a species of *Creseis*, not specifically identifiable. No benthic Foraminifera are present in this deposit. Siliceous remains are represented by a few spicule fragments.

Station 118 : Zanzibar Area ; depth 1789 metres ; Bigelow sample ; light grey Globigerina ooze ; mud 70·1% ; organic remains 29·9%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides conglobata.
Gl. rubra.
Gl. sacculifera.
Orbulina universa.
Pulleniatina obliquiloculata.
Sphæroidinella dehiscens.
Globorotalia menardii.
Gl. tumida.

Pteropoda.

Creseis sp.
Cuvierina columnella.
Cavolinia spp.
Atlanta sp.

Only one benthic Foraminiferan, a species of *Pyrgo*, was identified from this material. Sponge spicules are frequent and a few Radiolaria are present.

Station 119 : Zanzibar Area ; depth 1204 metres ; Bigelow sample and dried mud from Agassiz trawl ; light brown, clayey, Globigerina ooze ; mud 55·4% ; organic remains 44·6%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides conglobata.
Gl. rubra.
Orbulina universa.
Pulleniatina obliquiloculata.
Sphæroidinella dehiscens.
Globorotalia canariensis.
Gl. crassa.
Gl. menardii.
Gl. truncatulinoides.
Gl. tumida.

Pteropoda.

Cuvierina columnella.

Benthic remains :—

Foraminifera.

Rhabdammina abyssorum.
Rh. discreta.
Rh. linearis.
Marsipella elongata.
Tholosina bulla.
Hyperammina friabilis.
Dendrophrya ramosa.
Reophax nodulosus.
Ammodiscus incertus.
Ammodiscoides turbinatus.
Ammolagena clavata.
Cyclammina compressa.
Verneulina propinqua.
Triloculina sp.
Pyrgo depressa.
P. murrhina.
Lenticulina subalata.
Dentalina filiformis.
Nonion umbilicatulum.
Bolivinita quadrilatera.

A few rare fragments of Mollusca and a few Radiolaria occur, but no other animal remains.

Station 120 : Zanzibar Area ; depth 2931 metres ; Bigelow sample ; fawn-grey Globigerina ooze ; mud 67·2% ; organic remains 32·8%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides conglobata.
Gl. rubra.
Orbulina universa.
Pulleniatina obliquiloculata.
Sphæroidinella dehiscens.
Globorotalia menardii.
Gl. tumida.

No Pteropoda are present.

Benthic remains :—

Foraminifera.

Rhabdammina abyssorum.
Rh. abyssorum var. *radiata.*
Rh. discreta.
Rh. linearis.
Psammosphæra fusca.
Saccammina sphærica.
Hyperammina friabilis.
Reophax nodulosus.
Ammolagena clavata.

No Molluscan or Echinoderm remains are present in this deposit. Poriferan spicules are very rare.

Station 121 : Zanzibar Area ; depth 925 metres ; Bigelow sample ; grey-brown impure Globigerina ooze ; mud 72·7% ; organic remains 27·3%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides. *Pulleniatina obliquiloculata.*
Globigerinoides conglobata. *Globorotalia menardii.*
Gl. rubra. *Gl. tumida.*
Orbulina universa.

Pteropoda.

Limacina inflata. *Diacria quadridentata.*

Rare Gasteropod fragments and sponge spicules were the only benthic remains found in this deposit.

Station 122 : Zanzibar Area ; depth 745 metres ; Bigelow sample ; dark grey-brown calcareous mud with Foraminifera ; mud 81·1% ; organic remains 18·9%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides. *Orbulina universa.*
Gl. dubia. *Pulleniatina obliquiloculata.*
Globigerinoides conglobata. *Globorotalia menardii.*
Gl. rubra.

Pteropoda.

Creseis sp. *Cavolinia* sp.

Benthic remains are represented by frequent Gasteropod fragments and two Foraminifera, *Pyrgo* sp. and *Ophthalmidium inconstans*, neither of which is common. Poriferan remains are rare.

Station 123 : Zanzibar Area ; depth 256–366 metres ; dredge samples ; grey clayey mud with much quartz sand and rock fragments, but few animal remains ; mud and mineral grains 97·9% ; organic remains 2·1%.

Pelagic remains :—

Foraminifera.

Globigerina sp. *Globorotalia truncatulinoides.*
Orbulina universa.

Benthic remains :—

Foraminifera.

Bulimina pyrula. *Planulina wuellerstorfi.*
Chilostomella ovoidea.

In addition a few fragments of Pteropoda are present, and among benthic remains a few Echinoderm fragments and some plant remains derived from the land.

The rock fragments obtained are calcareous conglomerate. Some pieces show remains of Mollusca, Polyzoa and Foraminifera. The bottom here appears to be covered by a terrigenous mud interspersed with patches of conglomerate.

Station 125 : Zanzibar Area ; depth 805 metres ; Priestman grab sample ; brown, clayey mud with few organic remains ; mud 92·5% ; organic remains 7·5%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides rubra.
Gl. sacculifera.
Orbulina universa.
Pulleniatina obliquiloculata.
Globorotalia menardii.
Gl. truncatulinoides.

Pteropoda.

Limacina inflata.
Creseis virgula.

Benthic remains :—

Foraminifera.

Crithionina pisum var. *hispida.*
Hormosina globulifera.
Haplostiche dubia.
Ammodiscoides turbinatus.
Spiroplectammina milletti.
Textularia gramen.
T. sagittula.
Quinqueloculina sp.
Spiroloculina depressa.
Triloculina trigonula.
Pyrgo denticulata.
P. vespertilio.
Robulus costatus.
R. ? papillosus.
Lenticulina rotulata.
Nodosaria flinti.
Saracenaria italica.
Nonion umbilicatulum.
Elphidium craticulatum.
El. crispum.
Operculina granulosa.
Heterostegina suborbicularis.
Sorites marginalis.
Amphisorus hemprichi.
Marginopora vertebralis.
Alveolinella boscii.
Buliminella elegantissima.
Bulimina aculeata.
Bolivina seminuda.
Uvigerina aculeata.
U. asperula.
Siphogenerina bifrons.
S. striata var. *curta.*
Eponides præcinctus.
Rotalia papillosa.
Amphistegina radiata.
Laticarinina pauperata.
Gypsina globulus.
Carpenteria proteiformis.

Very young shells of Gastropoda and Lamellibranchiata and fragments of *Tubipora* and *Seriatopora* are the only other remains of bottom-living organisms present.

Station 126 : Zanzibar Area ; depth 209 metres ; coarse Priestman grab sample ; light brown mud and calcareous sand and gravel.

Chief components.	Frequency.	% coarse material.
Foraminifera . .	C .	2·3
Corals	VC .	18·2
Polychæta . . .	R .	0·1
Polyzoa . . .	R .	0·2
Echinodermata . .	F .	1·0
Crustacea . . .	R .	1·2

Chief components.	Frequency.	% coarse material.
Lamellibranchiata	R	3·1
Gasteropoda	F	6·5
Pteropoda	R	0·7
Algæ	VC	16·8
Other remains	A	49·9
		100·0

Pelagic remains :—

Foraminifera.

Globigerina sp.
Globorotalia menardii.

Pteropoda.

Creseis acicula.
Cr. virgula.
Diacria quadridentata.
Cavolinia longirostris.
Atlanta sp.

Benthic remains :—

Foraminifera.

Reophax sp.
Haplostiche dubia.
Textularia gramen.
T. sagittula.
Clavulina parisiensis.
Quinqueloculina sp.
Massilina arenaria.
Spiroloculina depressa.
Pyrgo comata.
P. sarsi.
Biloculinella globula.
Placopsilina cenomana.
Robulus orbicularis.
Robulus sp.
Vaginulina wetherellii
Nodosaria sp.
Nonion pompilioides.
Elphidium crispum.
Operculina granulosa.
Heterostegina depressa.
H. operculinoides.
H. suborbicularis.
Sorites marginalis.
Amphisorus hemprichi.
Marginopora vertebralis.
Amphistegina radiata.
Planorbulinella larvata.
Gypsina globulus.
Carpenteria proteiformis.
Homotrema rubrum.
Sporadotrema cylindricum.
Sp. mesentericum.

Corals.

Cycloseris sp.
Pachyseris sp.
Seriatopora sp.
Acropora sp.
Tubipora sp.

Remains of Alcyonacea and Hydrocorallinæ are also present. Otoliths and sponge spicules occur infrequently. Among Gasteropod remains a specimen of *Xenophora* sp. was recognized, but the majority of the Molluscan fragments are unidentifiable. Among the Crustacean remains *Balanus* valves are frequent.

Station 127 : Southern Arabian Sea ; depth 4091 metres ; Bigelow sample ; Globigerina ooze transitional to Red clay ; mud 51·1% ; organic remains 48·9%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides conglobata.
Gl. rubra.
Orbulina universa.
Pulleniatina obliquiloculata.
Sphæroidinella dehiscens.
Globorotalia menardii.
Gl. tumida.

No calcareous benthic remains are present and no Pteropod shells. A few sponge spicules and a few Radiolaria occur. This deposit and the following three are all transitional to Red clay. This one is the nearest to Globigerina ooze. That from Sta. 134 is most like Red clay, and has the smallest percentage (15·97) of Foraminiferal tests of the four. Sta. 134 is also the deepest of the three.

Station 128 : Southern Arabian Sea ; depth 4060 metres ; Bigelow sample ; Globigerina ooze transitional to Red clay, similar to the preceding ; mud 78·1% ; organic remains 21·9%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides conglobata.
Pulleniatina obliquiloculata.
Sphæroidinella dehiscens.
Globorotalia menardii.
Gl. tumida.

No Pteropod shells are present. Benthic organisms are represented by *Rotalia* sp., and, among siliceous organisms, by sponge spicules and Radiolaria.

Station 132 : Southern Arabian Sea ; depth 4082 metres ; Bigelow sample ; like Stas. 127 and 128, Globigerina ooze transitional to Red clay ; mud 75·2% ; organic remains 24·8%.

Most of the fragments of Foraminifera are unidentifiable. The following four pelagic species occur :—

Globigerina dubia.
Globigerinoides conglobata.
Pulleniatina obliquiloculata.
Globorotalia menardii.

Probably other species are represented among the fragments of tests. A very few Coccoliths occur in this deposit. Only one benthic Foraminiferan, *Pyrgo murrhina*, was found. Fragmentary Radiolaria and a few Diatom frustules are to be found in the deposit.

Station 133 : Southern Arabian Sea ; depth 3385 metres ; no deposit is available for this station. A single Foraminiferan, *Triloculina tricarinata*, was found in debris.

Station 134 : Southern Arabian Sea ; depth 4234 metres ; Bigelow sample ; like Stas. 127, 128 and 132, this is a transitional deposit, but in this case much nearer to Red clay ; mud 84·0% ; organic remains 16·0%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Gl. inflata.
Globigerinoides sacculifera.
Orbulina universa.
Pulleniatina obliquiloculata.
Sphæroidinella dehiscens.
Globorotalia menardii.
Gl. tumida.

Only one benthic Foraminiferan, *Virgulina subsquamosa*, occurred in the upper part of this deposit. A few *Lithocircus* sp. and *Coscinodiscus* sp. are the only siliceous remains present.

Station 135 : Southern Arabian Sea ; Bigelow sample ; Globigerina ooze ; mud 55·5% ; organic remains 44·5%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides conglobata.
Gl. rubra.
Gl. sacculifera.
Globigerinella æquilateralis.
Gl. digitata.
Orbulina universa.
Pulleniatina obliquiloculata.
Sphæroidinella dehiscens.
Globorotalia canariensis.
Gl. crassa.
Gl. menardii.
Gl. tumida.

Benthic remains :—

Foraminifera : Two species only, *Rotalia brœkhiana* and *Planulina wuellerstorfi*, were found in the surface deposit.

Pulleniatina obliquiloculata is very common in the surface deposit. Radiolarian skeletons are common at this station.

Station 137 : Maldive Area ; depth 46 metres ; Priestman grab samples ; fine grey-white, calcareous mud, smelling of sulphuretted hydrogen ; mud 91·1% ; organic remains 8·9%.

Chief components.	Frequency.	% coarse material.	% deposit.
Foraminifera	R	0·3	tr.
Echinodermata	F	3·3	0·3
Crustacea	F	3·3	0·3
Lamellibranchiata	F	5·4	0·5
Gasteropoda	A	80·2	7·1
Pteropoda	F	3·4	0·3
Other remains	R	4·1	0·4
		100·0	8·9

Pelagic remains :—

No pelagic Foraminifera were found.

Pteropoda.

Creseis acicula.
Creseis virgula.

Benthic remains :—

Foraminifera.

Textularia foliacea.
Operculina gaimardi.
O. granulosa.
Heterostegina suborbicularis.
Amphistegina radiata.

This deposit is probably true coral mud derived from the breakdown of calcareous animal and plant structures growing on the reef. According to an estimation made at

the time of collecting, the water drawn off from the mud contained 4·90 mgrm. H_2S per litre.

Station 139 : Maldive Area ; depth 57 metres ; Priestman grab samples ; fine, calcareous, shell and Foraminiferal sand ; mud 12·8% ; organic remains 87·2%.

Chief components.	Frequency.	% coarse material.	% deposit.
Foraminifera	A	61·2	53·4
Echinodermata	F	2·2	1·9
Crustacea	R	1·6	1·4
Lamellibranchiata	R	4·6	3·9
Gasteropoda	F	10·8	9·5
Halimeda	R	1·8	1·6
Other remains	VC	17·8	15·5
		100·0	87·2

The only pelagic organism found was a specimen of the Foraminiferan *Tretomphalus bulloides*.

Benthic remains :—

Foraminifera.

Textularia candeina.
T. conica.
T. foliacea.
T. gramen.
T. pseudotrochus.
Spiroloculina grateloupi.
Triloculina oblonga.
Tr. tricarinata.
Placopsilina cenomana.
Elphidium craticulatum.
Operculinella cumingi.
Operculina granulosa.
Heterostegina depressa.
Alveolinella boscii.
Amphistegina radiata.
Cymbaloporetta bradyi.
C. squamosa.
Gypsina vesicularis.
Carpenteria proteiformis.
C. utricularis.
Sporadotrema cylindricum.
Miniacina miniacea.

Fragments of corals, *Cryptohelia*, Alcyonacea, Scaphopoda and Polychæta also occur in this deposit (see Pl. III, fig. 3).

Station 141 : Maldive Area ; depth 44 metres ; Priestman grab samples ; calcareous sand with much *Halimeda* ; fine sand 49·4% ; organic remains 50·6%.

Chief components.	Frequency.	% coarse material.	% deposit.
Foraminifera	A	13·0	6·6
Lamellibranchiata	C	9·2	4·7
Gasteropoda	R	3·9	2·0
Halimeda	A	41·0	20·7
Other remains	VC	32·9	16·6
		100·0	50·6

Benthic remains :—

Foraminifera.

Textularia candeina.
Quinqueloculina kerimbatica.
Q. parkeri.
Spiroloculina tenuissima.
Schlumbergerina alveoliniformis.
Triloculina tricarinata.
Robulus sp.
Elphidium craticulatum.
Operculinella cumingi.
Operculina gaimardi.
O. granulosa.
Heterostegina depressa.
Borelis melo.
Alveolinella boscii.
Amphistegina radiata.
Acervulina inhærans.
Gypsina globulus.
Miniacina miniacea.

Corals, Hydrocorallinæ, Alcyonarian spicules, Echinoderm and Crustacean fragments occur in small quantities. Pelagic remains are practically absent, the only organism observed being *Atlanta* sp.

Station 142a : Maldive Area ; depth 31 metres ; Priestman grab samples ; coral mud smelling of H_2S ; mud 59·7% ; organic remains 40·3%.

Chief components.	Frequency.	% coarse material.	% deposit.
Foraminifera	VC	4·5	1·8
Alcyonaria	F	1·0	0·4
Echinodermata	R	0·5	0·2
Crustacea	F	4·4	1·8
Lamellibranchiata	A	33·3	13·4
Gasteropoda	C	16·1	6·5
Halimeda	R	2·0	0·8
Other remains	A	38·2	15·4
		100·0	40·3

The animal remains are very finely triturated. This accounts for the large percentage of " Other remains " in the above table, all the unidentifiable material being included under this head.

Benthic remains :—

Foraminifera.

Textularia conica.
T. foliacea.
T. haueri.
Quinqueloculina reticulata.
Massilina inæqualis.
Elphidium craticulatum.
Operculina gaimardi.
Operculina granulosa.
Heterostegina depressa.
Amphisorus hemprichi.
Borelis melo.
Alveolinella boscii.
Amphistegina radiata.
Gypsina globulus.

Alcyonarian spicules, Hydrocorallinæ, *Seriatopora*, otoliths and Scaphopoda occur in small numbers. The Echinoderm remains are chiefly those of Clypeastroidea. Very few pelagic Foraminifera or Pteropoda are present. Estimations made when the sample was collected gave the amount of H_2S present as 3·92 mgrm. per litre of water aspirated off from the mud.

Station 142b : Maldive Area ; depth 37 metres ; Priestman grab samples ; coral mud with very few coarse fragments ; mud 93·0% ; organic remains 7·0%.

Chief components.	Frequency.	% coarse material.	% deposit.
Echinodermata	C	7·0	0·5
Crustacea	VC	11·2	0·8
Lamellibranchiata	VC	21·1	1·5
Gasteropoda	A	51·5	3·6
Pteropoda	R	0·8	tr.
Other remains	F	8·4	0·6
		100·0	7·0

Benthic remains :—

Foraminifera.

Quinqueloculina ferussacii.
Spiroloculina canaliculata.
Sp. grateloupi.
Operculina gaimardi.
O. granulosa.

Poriferan spicules, Polyzoa, Scaphopoda, otoliths and bones of fish and fragments of *Halimeda* occur sparingly. The Echinoderm remains are again largely those of Clypeastroidea. No large fragments of any of the above organisms occur in this deposit. Slightly less H_2S was found at this station, 2·26 mgrm. per litre of aspirated water, as against 3·92 mgrm. at the last station (see Pl. III, fig. 6).

Station 143 ; Maldive Area ; depth 797 metres ; Agassiz trawl sample ; grey-green Foraminiferal sand ; mud 22·0% ; organic remains 78·0%.

This sample has probably had some of the finer material washed out during its passage to the surface, and so the above figures can only be regarded as very approximate.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides conglobata.
Gl. rubra.
Orbulina universa.
Pulleniatina obliquiloculata.
Globorotalia canariensis.
Gl. menardii.

Pteropoda.

Limacina inflata.
Creseis acicula.

Benthic remains :—

Foraminifera.

Reophax scorpiurus.
Haplostiche dubia.
Haplophragmoides scitulum.
Ammobaculites calcareum.
Textularia conica.
T. gramen.
T. sagittula.
Verneulina bradyi.
Gaudryina baccata.
Clavulina parisiensis.
Massilina arenaria.
Spiroloculina depressa.
Sigmoilina schlumbergeri.
Pyrgo anomala.
P. milletti.
P. murrhina.
Cornuspira involvens.
Robulus sp.

Saracenaria italica.
Polymorphina lanceolata.
Heterostegina depressa.
Alveolinella boscii.
Bulimina elongata.
Siphogenerina columellaris.
Epistomina elegans.
Cancris auriculus.
Amphistegina radiata.
Chilostomella ovoidea.

Ostracod valves, otoliths and Echinoderm spines also occur. The greenish colour of this deposit is due to the contents of the Foraminiferal tests. When the tests are dissolved away, green casts, presumably of glauconite, are left.

Station 144 : Maldive Area ; depth 31 metres ; Priestman grab samples ; coarse sand and gravel composed mainly of molluscan and *Halimeda* fragments ; mud 57·3% ; organic remains 42·7%.

Chief components.	Frequency.	% coarse material.	% deposit.
Foraminifera	R	1·4	0·6
Corals	F	4·4	1·9
Echinodermata	R	0·8	0·3
Lamellibranchiata	C	12·0	5·1
Gasteropoda	A	50·1	21·4
Halimeda	VC	15·6	6·7
Calcareous conglomerate	C	15·7	6·7
		100·0	42·7

No pelagic remains are present in this deposit.
Benthic remains :—
Foraminifera.

Textularia candeina.
T. conica.
Operculinella cumingi.
Heterostegina depressa.
H. suborbicularis.
Marginopora vertebralis.
Borelis melo.
Alveolinella boscii.
Amphistegina radiata.
Miniacina miniacea.

Alcyonarian spicules, Polychæt tubes, Scaphopods and fragments of *Lithothamnion* occur sparingly. *Balanus* compartments are among the Crustacean materials present. Clypeastroid fragments are again more numerous than those of other Echinoidea (see Pl. III, fig. 4).

Some of the material is cemented together, forming a loose conglomerate. There is no H_2S present at this station.

Station 145 : Maldive Area ; depth 494 metres ; Baillie rod sample ; grey-green mud and sand ; mud 51·7% ; organic remains 48·3%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides conglobata.
Gl. rubra.
Gl. sacculifera.
Orbulina universa.
Pulleniatina obliquiloculata.
Globorotalia canariensis.
Gl. menardii.

Pteropoda.

Limacina bulimoides.
L. inflata.
Creseis acicula.
Hyalocylis striata.
Diacria quadridentata.

Benthic remains :—

Foraminifera.

Reophax sp.
Haplostiche dubia.
Spiroplectammina milletti.
Textularia sagittula.
Gaudryina baccata.
Massilina arenaria.
Triloculina oblonga.
Pyrgo vespertilio.
Biloculinella globula.
Bulimina aculeata.
Uvigerina schwageri.
Siphogenerina columellaris.
Epistomina elegans.
Cancris auriculus.
Cymbaloporetta squamosa.
Chilostomella ovoidea.
Planulina wuellerstorfi.

This deposit is a mixture of coral mud, Foraminiferal sand and Globigerina ooze, of which it is perhaps nearest to the Globigerina ooze. A few otoliths occur.

Station 147 : Maldive Area ; depth 27 metres ; Priestman grab samples ; coral mud and gravel ; mud 93·3% ; organic remains 6·7%.

Chief components.	Frequency.	% coarse material.	% deposit.
Corals	F	7·8	0·5
Polychæta	A	28·6	1·9
Echinodermata	C	11·7	0·8
Crustacea	A	18·3	1·2
Lamellibranchiata	C	15·4	1·0
Gasteropoda	C	14·5	1·0
Pteropoda	R	1·1	0·1
Halimeda	R	2·6	0·2
		100·0	6·7

Pelagic remains are represented by *Creseis acicula* only. Two benthic Foraminifera only were found, *Heterostegina depressa* and *Amphistegina radiata*. A few Polyzoan and Scaphopod remains occur.

No H_2S was present in this deposit from the lagoon.

Station 149 : Maldive Area ; depth 238 metres ; coarse Priestman grab sample only ; coarse gravel and sand composed of shell, coral and coralline algæ.

Chief components.	Frequency.	% coarse material.
Foraminifera	C	5·0
Corals	A	20·7
Hydrocorallinæ	R	0·7
Alcyonaria	R	0·3
Polychæta	R	tr.
Polyzoa	R	0·5
Echinodermata	R	0·3
Crustacea	R	0·3
Lamellibranchiata	R	1·1
Gasteropoda	F	10·9
Pteropoda	R	0·2
Halimeda	A	28·0
Other remains	A	32·0
		100·0

Pelagic remains :—

Foraminifera.

Globigerina bulloides. *Globorotalia menardii.*
Pulleniatina obliquiloculata.

Benthic remains :—

Foraminifera.

Haplostiche dubia. *Amphisorus hemprichi.*
Textularia agglutinans. *Marginopora vertebralis.*
Quinqueloculina kerimbatica. *Alveolinella boscii.*
Pyrgo denticulata. *Siphogenerina raphanus.*
P. milletti. *Amphistegina radiata.*
Biloculinella globula. *Calcarina defranci.*
Robulus ? lucidus. *Cymbaloporetta bradyi.*
R. orbicularis. *Cibicides lobatulus.*
Lenticulina rotulata. *Planorbulinella larvata.*
Lingulina grandis. *Gypsina globulus.*
Elphidium craticulatum. *Carpenteria monticularis.*
Operculinella cumingi. *C. proteiformis.*
Heterostegina depressa. *C. utricularis.*
H. operculinoides. *Sporadotrema cylindricum.*
H. suborbicularis. *Sp. mesentericum.*
Sorites marginalis. *Miniacina miniacea.*

Station 152 : Maldive Area ; depth 878 metres ; dredge samples ; grey impure Globigerina ooze ; mud 34·4% ; organic remains 65·6%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides. *Globigerinoides rubra.*
Gl. dubia. *Gl. sacculifera.*
Globigerinoides conglobata. *Globigerinella digitata.*

Orbulina universa.
Pulleniatina obliquiloculata.
Sphæroidinella dehiscens.
Globorotalia canariensis.
Gl. menardii.
Gl. truncatulinoides.
Gl. tumida.

Pteropoda.

Limacina bulimoides.
L. inflata.
L. trochiformis.
Creseis virgula.
Diacria quadridentata.

Benthic remains :—

Foraminifera.

Aschemonella ramuliformis.
Pyrgo murrhina.
Dentalina elegans.
Saracenaria italica.
Elphidium crispum.
Sorites marginalis.
Angulogerina carinata.
Epistomina elegans.

Poriferan spicules and pieces of siliceous sponge skeletons are fairly common, but for the most part microscopic. The coarse sievings from a large bulk of deposit yielded a few worn coral fragments, a few mollusc shells, Echinoderm remains, and pieces of calcareous rock containing shell fragments and Foraminifera.

Station 153 : Maldive Area ; depth 256 metres ; pieces of calcareous rock and a few animal remains from a dredge sample of the bottom are the only materials available. The following Foraminifera are represented :

Pelagic :—

Globorotalia canariensis.
Gl. crassa.
Tretomphalus bulloides.

Benthic :—

Textularia conica.
Nodosaria scalaris.
Robulus sp.
Marginulina sp.
Marginopora vertebralis.
Angulogerina carinata.
Cibicides refulgens.
C. biserialis.
Planorbulinoides retinaculata.
Miniacina miniacea.

Fragments of Lamellibranchiata, Gasteropoda (incl. *Xenophora* sp.), Echinodermata, Corals (*Diaseris* sp.), Crustacea and Polychæta and otoliths occur sparingly. Shell fragments and Foraminifera can be seen in the calcareous conglomerate.

Station 156 : Maldive Area ; depth 1317 metres ; Baillie rod sample ; Globigerina ooze ; mud 67·2% ; organic remains 32·8%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides conglobata.
Gl. rubra.
Gl. sacculifera.
Globigerinella digitata.
Orbulina universa.
Pulleniatina obliquiloculata.
Sphæroidinella dehiscens.
Globorotalia canariensis.
Gl. menardii.

Benthic remains :—

Foraminifera.

Clavulina communis. *Epistomina elegans.*
Nodosaria pauperata. *Cibicides lobatulus.*

A few fragments of Coral (? *Galaxea* sp.) are present.

Station 157 : Maldive Area ; depth 229 metres ; calcareous rock.

Very few incrusting organisms are present. The Foraminifera, *Carpenteria monticularis*, *C. proteiformis* and *C. utricularis* are present, and also the Stylasterine *Cryptohelia stenopoma*. A few young solitary corals and fragments of Oculinidæ and *Flabellum* sp. occur. The following Pteropoda occur :

Cuvierina columnella. *Cavolinia longirostris.*
Cavolinia gibbosa. *C. uncinata.*
C. globulosa.

Station 158 : Maldive Area ; depth 914 metres ; coarse Agassiz sample only ; calcareous rock as at the previous station.

Pelagic remains :—

Foraminifera.

Globigerina bulloides. *Pulleniatina obliquiloculata.*
Globigerinoides conglobata. *Globorotalia menardii.*
Orbulina universa.

Benthic remains :—

Foraminifera.

Clavulina communis. *Cancris auriculus.*
Sorites marginalis. *Laticarinina pauperata.*
Bulimina ovata. *Cibicides lobatulus.*
Gyroidina soldani.

Molluscan remains are rare. Only one species of Pteropod, *Cavolinia uncinata*, is present. Brachiopod valves, a shell of *Verruca* sp., and *Cryptohelia* sp. were found.

Station 159 : Maldive Area ; depth 1280 metres ; trawl samples ; cream-coloured calcareous, probably coral, mud ; mud 94·5% ; organic remains 5·5%.

Pelagic remains :—

Foraminifera.

Globorotalia canariensis. *Globorotalia crassa.*

Pteropoda.

Creseis acicula. *Hyalocylis striata.*

Benthic remains :—

Foraminifera.

Textularia agglutinans. *Triloculina oblonga.*
T. foliacea. *T. tricarinata.*
Gaudryina baccata. *Cymbaloporetta bradyi.*
Spiroloculina grateloupi var. *acescata.* *C. squamosa.*
Cymbaloporella tabellæformis.

Young hyaline shells of Lamellibranchiata and Gasteropoda make up the rest of the organic remains.

Station 160 : Maldive Area ; depth 37 metres ; Priestman grab samples ; coral mud smelling of H_2S ; mud 94·6% ; organic remains 5·4%.

Chief components.	Frequency.	% coarse material.	% deposit.
Crustacea	VC	10·0	0·5
Lamellibranchiata	A	36·6	2·0
Gasteropoda	F	10·7	0·6
Pteropoda	A	20·6	1·1
Halimeda	R	1·8	0·1
Other animals	R	0·4	tr.
Calcareous residue	C	19·9	1·1
		100·0	5·4

Pelagic remains :—

Foraminifera.

Globigerina bulloides. *Globigerinella digitata.*
Gl. dubia. *Orbulina universa.*
Globigerinoides conglobata. *Globorotalia canariensis.*
Gl. rubra. *Gl. crassa.*
Gl. sacculifera. *Gl. menardii.*

Pteropoda.

Creseis acicula. *Cavolinia longirostris.*
Diacria quadridentata.

Benthic remains :—

Foraminifera.

Bathysiphon filiformis. *Dentalina emaciata.*
Aschemonella ramuliformis. *Nodosaria pyrula.*
Trochamminoides proteus. *Nonion boueanum.*
Clavulina communis. *Epistomina elegans.*
Pyrgo vespertilio. *Laticarinina pauperata.*

A few fish-bones are present in this deposit. *Globigerinella digitata* is much commoner at this station than elsewhere.

Station 161 : Maldive Area ; depth 46 metres ; Priestman grab samples ; coarse coral and shell sand and mud ; mud 68·5% ; organic remains 31·5%.

Chief components.	Frequency.	% coarse material.	% deposit.
Foraminifera	A	14·0	4·4
(*Alveolinella boscii*)	(A)	(4·1)	(1·3)
Coral	R	1·8	0·5
Polychæta	R	0·5	0·2
Echinodermata	R	0·2	0·1
Crustacea	R	0·7	0·2
Lamellibranchiata	C	12·1	3·8
Gasteropoda	C	19·9	6·3
Halimeda	C	7·8	2·4
Other remains	A	43·0	13·6
		100·0	31·5

Pelagic remains :—

Only a few fragments of Pteropoda.

Benthic remains :—

Foraminifera.

Textularia candeina.
T. conica.
T. foliacea.
Massilina australis.
Elphidium craticulatum.
El. crispum.
Operculinella cumingi.
Operculina granulosa.
Heterostegina depressa.
Marginopora vertebralis.
Borelis melo.
Alveolinella boscii.
Amphistegina radiata.
Calcarina defranci.
Homotrema rubrum.
Sporadotrema cylindricum.
Miniacina miniacea.

Corals are represented by worn fragments of perforate corals and by small specimens of *Diaseris* sp. Many of the Polychæt tubes are formed of agglutinated Foraminifera and shell fragments. The abundance of tests of *Alveolinella boscii* and *Operculinella cumingi* is noteworthy.

Station 163 : Maldive Area ; depth 274 metres ; Priestman grab samples ; greenish-white mud with coral and shell sand ; mud 64·1% ; organic remains 35·9%.

Chief components.	Frequency.	% coarse material.	% deposit.
Foraminifera	C	4·5	1·6
Alcyonaria	F	1·2	0·4
Hydrocorallinæ	F	1·2	0·4
Corals	F	4·1	1·5
Polyzoa	F	2·8	1·0
Echinodermata	F	2·3	0·8
Crustacea	F	4·9	1·8
Lamellibranchiata	F	5·7	2·1
Gasteropoda	VC	19·0	6·8
Pteropoda	R	0·9	0·3
Pisces	R	0·8	0·3
Halimeda	F	3·4	1·2
Other remains	A	49·2	17·7
		100·0	35·9

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides conglobata.
Gl. sacculifera.
Orbulina universa.
Pulleniatina obliquiloculata.
Globorotalia menardii.

Pteropoda.

Limacina inflata.
Creseis acicula.
Cr. virgula.
Clio cuspidata.
Diacria quadridentata.
Cavolinia uncinata.
Atlanta sp.

Benthic remains :—

Foraminifera.

Textularia rugosa.
Triloculina oblonga.
Lenticulina rotulata.
Operculinella cumingi.
Operculina granulosa.
Heterostegina depressa.
H. operculinoides.
H. suborbicularis.
Sorites marginalis.
Amphisorus hemprichi.
Marginopora vertebralis.
Borelis melo.
Alveolinella boscii.
Uvigerina pygmæa.
Rotalia calcar.
Amphistegina radiata.
Calcarina defranci.
Chilostomella ovoidea.
Homotrema rubrum.
Sporadotrema mesentericum.
Miniacina miniacea.

The Gasteropod remains are riddled with holes presumably the borings of sponges or algæ. The green colour of this deposit appears to be due to the presence of organic matter and chlorophyll and not to glauconite (see Pl. III, fig. 5).

Station 164 : Maldive Area ; depth 183 metres ; Priestman grab samples ; greenish calcareous sand and mud, chiefly shell and coral debris ; mud 69·5% ; organic remains 30·5%.

Chief components.	Frequency.	% coarse material.	% deposit.
Foraminifera	C	4·8	1·5
Alcyonaria	F	1·1	0·3
Corals	VC	16·8	5·1
Polychæta	F	2·6	0·8
Polyzoa	VC	6·3	1·9
Echinodermata	R	0·9	0·3
Crustacea	F	4·6	1·4
Lamellibranchiata	F	5·2	1·6
Gasteropoda	VC	24·1	7·3
Pteropoda	R	0·5	0·2
Halimeda	VC	11·5	3·5
Other animals	R	0·1	tr.
Other remains	VC	21·5	6·6
		100·0	30·5

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides conglobata.
Globigerinella æquilateralis.
Orbulina universa.
Pulleniatina obliquiloculata.
Sphæroidinella dehiscens.
Globorotalia canariensis.
Gl. menardii.

Pteropoda.

Limacina inflata.
Creseis acicula.
Clio pyramidata.
Diacria quadridentata.
Cavolinia longirostris.
C. uncinata.
Atlanta sp.

Benthic remains :—

Foraminifera.

Textularia agglutinans.
T. rugosa.
Verneulina triquetra.
Gaudryina rugulosa.
Pyrgo denticulata.
Lenticulina d'Orbignyi.
L. rotulata.
Nodosaria subscalaris var. *paucicostata.*
Lingulina grandis.
Elphidium craticulatum.
Operculinella cumingi.
Operculina gaimardi.
Heterostegina depressa.
H. operculinoides.
Heterostegina suborbicularis.
Sorites marginalis.
Borelis melo.
Alveolinella boscii.
Rotalia calcar.
Amphistegina radiata.
Calcarina defranci.
Cymbaloporetta bradyi.
Planorbulinella larvata.
Gypsina globulus.
Homotrema rubrum.
Sporadotrema cylindricum.
Sp. mesentericum.
Miniacina miniacea.

A few fragments of Hydrocorallinæ and Scaphopoda and otoliths occur. The green colour again appears to be due to organic matter.

Station 165 : Maldive Area ; depth 366 metres ; Priestman grab sample ; greenish calcareous sand ; mud 13·7% ; organic remains 86·3%.

It is possible that this sample is not intact, some of the fine mud having, in all probability, been washed out.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides conglobata.
Gl. sacculifera.
Orbulina universa.
Pulleniatina obliquiloculata.
Sphæroidinella dehiscens.
Globorotalia menardii.

Pteropoda.

Limacina bulimoides.
L. inflata.
Cavolinia longirostris.
Atlanta sp.

Benthic remains :—

Foraminifera.

Reophax sp.
Ammobaculites calcareum.
Textularia sp.
Quinqueloculina sp.
Pyrgo denticulata.
P. vespertilio.
Biloculinella globula.
Dentalina filiformis.
Elphidium crispum.
Heterostegina suborbicularis.
Amphisorus hemprichi.
Alveolinella boscii.
Cancris auriculus.
Amphistegina radiata.
Calcarina defranci.
Miniacina miniacea.

Fragments of Alcyonaria, Echinodermata, Pteropoda, Gasteropoda and Lamellibranchiata occur, but there is no large amount of sifted material from which to work out their relative abundance.

Station 166 : Central Arabian Sea ; depth 4793 metres ; Bigelow sample ; pure Red clay with only a trace of calcium carbonate. Neither calcareous nor siliceous remains were found in this deposit.

Station 167 : Central Arabian Sea ; depth 4042 metres ; Bigelow sample ; transitional between Globigerina ooze and Red clay ; mud 86·6% ; organic remains 13·4%.

Pelagic remains (see Pl. II, fig. 6) :—

Foraminifera.

Globigerina bulloides.
Globigerinoides conglobata.
Pulleniatina obliquiloculata.
Sphæroidinella dehiscens.
Globorotalia menardii.
Gl. tumida.

No benthic remains were found in this deposit. Radiolarian skeletons were present but rare.

Station 170 : Central Arabian Sea ; depth 3676 metres ; Baillie rod sample ; creamy-grey Globigerina ooze.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides rubra.
Globigerinoides sacculifera.
Globorotalia menardii.
Gl. tumida.

Diatoms.

Coscinodiscus sp.

No benthic remains were found. This ooze is exceedingly fine, and contains very few whole Foraminiferal tests and no other calcareous organisms. Siliceous remains are represented by *Coscinodiscus* sp. and a few Radiolaria, including *Lithocircus* sp.

Station 173 : Central Arabian Sea ; depth 4499 metres ; Bigelow sample ; Globigerina ooze ; mud 76·6% ; organic remains 23·4%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Pulleniatina obliquiloculata.
Globorotalia menardii.
Gl. tumida.

Benthic remains :—

Foraminifera.

Nodosaria sp.
Chilostomella ovoidea.

Siliceous remains are represented by *Coscinodiscus* sp., Radiolaria and Poriferan spicules ; all are rare.

Station 175 : Gulf of Aden ; depth 1618 metres ; Bigelow sample ; green calcareous mud ; mud 89·7% ; organic remains 10·3%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides rubra.
Gl. sacculifera.
Hastigerina pelagica.
Orbulina universa.
Pulleniatina obliquiloculata.
Globorotalia canariensis.
Gl. crassa.
Gl. menardii.
Gl. tumida.

Benthic remains :—

Foraminifera.

Sigmoilina edwardsi.
Pyrgo murrhina.
P. sarsi.
Nonion umbilicatulum.
Bulimina aculeata.
B. pyrula.
Virgulina squamosa.
Uvigerina pygmæa.

A few otoliths, sponge spicules, Radiolaria and *Coscinodiscus* sp. are present. The green colour is largely due to the presence of organic matter.

Station 176 : Gulf of Aden ; depth 695 metres ; Agassiz trawl sample ; green coprolitic and Globigerina mud ; mud 44·6% ; fæcal pellets and fine animal remains 49·3% ; larger organic remains 6·1%.

Chief components.	Frequency.	% coarse material.	% deposit.
Foraminifera	A	4·7	0·3
Foraminifera (as Polychæt tubes)	A	16·9	1·0
Porifera	R	0·2	tr.
Corals	F	6·1	0·4
Polychæta	R	0·6	tr.
Echinodermata	F	2·3	0·2
Crustacea	R	0·4	tr.
Lamellibranchiata	C	9·2	0·6
Gasteropoda	VC	27·9	1·7
Pteropoda	VC	18·2	1·1
Scaphopoda	F	3·7	0·2
Pisces	C	6·2	0·4
Other remains	R	3·6	0·2
		100·0	6·1

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides sacculifera.
Orbulina universa.
Pulleniatina obliquiloculata.
Globorotalia canariensis.
Gl. menardii.

Pteropoda.

Limacina inflata.
Creseis acicula.
Hyalocylis striata.
Clio pyramidata.
Cuvierina columnella.
Diacria quadridentata.
Cavolinia longirostris.
C. uncinata.
Atlanta sp.

Benthic remains :—

Foraminifera.

Ammobaculites calcareum.
Spiroplectammina milletti.
Textularia sagittula.
Gaudryina baccata.
Clavulina communis.
Spiroloculina depressa.
Pyrgo murrhina.
Robulus calcar.
Lenticulina calcarata.
Nodosaria flinti.
Nodosaria radicula.
N. subscalaris.
Uvigerina pygmæa.
Siphogenerina striata var. *curta.*
Epistomina elegans.
Cancris auriculus.
Ehrenbergina pacifica.
Chilostomella ovoidea.
Planulina wuellerstorfi.
Cibicides lobatulus.

Vertebræ, other bones and otoliths of fish, and sharks' teeth occur in this deposit. Lamellibranch remains are common, including *Cuspidaria* sp., and *Amussium* sp. Gasteropod remains include broken shells of *Xenophora*, *Ranella*, *Pleurotoma*, *Solarium* and *Ianthina*. Scaphopoda are more frequent than usual; a few fragments of Cephalopod jaws occur. Many of the Polychæt tubes are formed almost entirely of Foraminifera, particularly *Globorotalia menardii*. These agglutinated tubes have been assessed separately in the above table. Small *Globigerinæ* are very common in this deposit, and form roughly half of the 49·3% of fæcal pellets and fine remains. Mineral grains, larger than silt size, are very rare at this station.

Station 178: Gulf of Aden; depth 91 metres; Priestman grab samples; green, calcareous sand; fine sand 76·0%; organic remains 24·0%.

Chief components.	Frequency.	% coarse material.	% deposit.
Foraminifera	R	1·0	0·3
Polychæta	R	1·0	0·3
Polyzoa	R	0·4	0·1
Echinodermata	R	1·4	0·3
Crustacea	R	0·9	0·2
Lamellibranchiata	F	7·7	1·9
Gasteropoda	VC	20·8	5·0
Pteropoda	R	0·1	tr.
Scaphopoda	R	0·1	tr.
Pisces	R	0·8	0·2
Lithothamnion	R	2·9	0·7
Other remains	A	62·6	14·9
Quartz grains	R	0·3	0·1
		100·0	24·0

Pelagic remains :—

Foraminifera.

Globigerina bulloides.

Pteropoda.

Creseis acicula. *Cavolinia longirostris.*

Clio pyramidata.

Benthic remains :—

Foraminifera.

Haplophragmoides grandiformis.	*Elphidium macellum.*
Textularia agglutinans.	*Operculina gaimardi.*
Spiroloculina grateloupi.	*O. granulosa.*
Triloculina tricarinata.	*Heterostegina operculinoides.*
Robulus sp.	*Sorites marginalis.*
Nodosaria scalaris.	*Rotalia papillosa.*
Vaginulina linearis.	*Amphistegina radiata.*
Sigmoidella elegantissima.	*Planorbulinella larvata.*
Polymorphina ovata.	*Miniacina miniacea.*

A few Scaphopoda of the genus *Cadulus* and a few fragments of the bivalve, *Venus torresiana*, occur. Apart from the Gasteropoda and to a lesser extent the Lamellibranchiata all the remains are rare. Alcyonarian spicules and small solitary corals occur occasionally.

A large proportion of the organic remains are worn and unidentifiable calcareous grains. Identifiable remains are comparatively rare. Very little fine mud is present in the samples. This may be due to washing during the passage of the material through the water. Alternatively, this may be the natural state of the deposit, especially as all the remains are much broken and worn, and often rounded as if water-worn (see Pl. II, fig. 2).

Station 179a : Gulf of Aden ; depth 310 metres ; Priestman grab and Agassiz trawl samples ; green, sandy mud ; mud 84·8% ; organic remains and rock fragments 15·2%.

Chief components.	Frequency.	% coarse material.	% deposit.
Lamellibranchiata	C	9·1	1·4
Gasteropoda	F	9·4	1·4
Pteropoda	VC	14·4	2·2
Scaphopoda	C	11·1	1·7
Other remains	A	56·0	8·5
		100·0	15·2

The " Other remains " are chiefly rock fragments.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.	*Globigerinella æquilateralis.*
Gl. dubia.	*Orbulina universa.*
Globigerinoides conglobata.	*Globorotalia canariensis.*
Gl. sacculifera.	*Gl. menardii.*

Pteropoda.

Limacina inflata.
L. trochiformis.
Creseis acicula.
Cr. virgula.
Clio pyramidata.
Cavolinia longirostris.
Atlanta sp.

Benthic remains :—

Foraminifera.

Textularia sagittula var. *atrata.*
Massilina australis.
Spiroloculina grateloupi.
Nonion scaphum.
Bulimina pupoides.
Bolivina amygdalæformis.
B. beyrichi.
B. simpsoni.
Uvigerina brunnensis.
Uvigerina pygmæa.
U. tenuistriata.
Siphogenerina bifrons.
Angulogerina carinata.
Cancris auriculus.
Cymbaloporetta bradyi.
Cymbaloporella tabellæformis.
Chilostomella ovoidea.
Cibicides lobatulus.

Animal remains in this deposit form only 6·7% of the 15·2% coarse material given in the above table. The rest of this is rock fragments and some unidentified particles. Otoliths and Echinoderm remains occur infrequently. The Pteropod remains are all broken with the exception of the small shells of *Limacina*. Primordial shells of *Creseis* and *Clio* are very common in the fine material sifted out.

Station 179b : Gulf of Aden ; depth 275 metres ; Priestman grab samples ; green, sandy mud ; mud 92·2% ; organic remains 7·8%.

Chief components.	Frequency.	% coarse material.	% deposit.
Corals	R	1·2	0·1
Polychæta	R	1·7	0·1
Echinodermata	A	24·7	1·9
Crustacea	R	1·3	0·1
Lamellibranchiata	VC	19·6	1·5
Gasteropoda	VC	27·5	2·1
Pteropoda	VC	13·5	1·1
Pisces	R	1·0	0·1
Other remains	F	10·1	0·8
		100·0	7·8

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Globigerinoides sacculifera.
Globigerinella æquilateralis.
Globorotalia menardii.

Pteropoda.

Limacina inflata.
L. trochiformis.
Creseis acicula.
Cr. virgula.
Hyalocylis striata.
Clio pyramidata.
Diacria quadridentata.
Cavolinia longirostris.
C. uncinata.
Atlanta sp.

Benthic remains :—

Foraminifera.

Textularia gramen.
T. pseudocarinata.
Spiroloculina depressa.
Triloculina sp.
Robulus sp.
Elphidium crispum.
Heterostegina operculinoides.
Uvigerina pygmæa.
Amphistegina radiata.
Ehrenbergina pacifica.
Carpenteria utricularis.

Fragments of *Lithothamnion* and sponge spicules occur rarely. Valves of *Venus torresiana* are common.

Station 180 : Gulf of Aden ; depth 397 metres ; Priestman grab samples ; green sandy mud ; mud 92·7% ; organic remains 7·3%.

Chief components.	Frequency.	% coarse material.	% deposit.
Foraminifera	F	0·1	tr.
Echinodermata	C	7·6	0·5
Crustacea	R	0·1	tr.
Lamellibranchiata	A	54·6	4·0
Gasteropoda	R	5·0	0·4
Pteropoda	A	26·3	1·9
Scaphopoda	F	2·3	0·2
Pisces	F	3·2	0·2
Other remains	R	0·8	0·1
		100·0	7·3

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides conglobata.
Gl. rubra.
Globigerinoides sacculifera.
Globigerinella æquilateralis.
Orbulina universa.
Globorotalia menardii.

Pteropoda.

Limacina inflata.
Creseis acicula.
Cr. virgula.
Hyalocylis striata.
Clio pyramidata.
Diacria quadridentata.
Cavolinia longirostris.
C. uncinata.
Atlanta sp.

Benthic remains :—

Foraminifera.

Haplostiche dubia.
Ammomarginulina foliacea.
Textularia goesi.
Lenticulina sp.
Elphidium jenseni.
Bulimina pupoides.
B. pyrula.
Uvigerina pygmæa.
Augulogerina carinata.

The commonest constituents are *Limacina* shells, closely followed by those of *Creseis.*

Globigerina spp. and fæcal pellets are next in order of frequency. The latter make up almost half of the finer material. Shell remains are almost all of *Venus torresiana*, with a few fragments of *Amussium* or related genus. Many of the valves show holes bored by carnivorous Gasteropoda. A species of *Cadulus* is represented among the Scaphopod remains.

Station 181 : Gulf of Aden ; depth 1982 metres ; Bigelow sample ; Globigerina ooze : mud 75·6% ; organic remains 24·4%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides conglobata.
Gl. rubra.
Orbulina universa.
Pulleniatina obliquiloculata.
Globorotalia canariensis.
Gl. crassa.
Gl. menardii.
Gl. truncatulinoides.
Gl. tumida.

Benthic remains :—

Foraminifera.

Clavulina communis.
Pyrgo depressa.
Lagena distoma.
Planulina wuellerstorfi.

A few sponge spicules are the only other benthic remains. These and rare Radiolaria are the only siliceous structures in this deposit.

Station 183 : Gulf of Aden ; depth 1105 metres ; Bigelow sample ; calcareous green mud ; mud 93·4% ; organic remains 6·6%. The following Foraminifera were the only calcareous organisms present :

Pelagic species :—

Globigerina bulloides.
Gl. dubia.
Globigerinoides rubra.
Orbulina universa.
Pulleniatina obliquiloculata.
Globorotalia canariensis.
Gl. menardii.
Gl. tumida.

Benthic species :—

Pyrgo depressa.
Lagena marginata.
Bulimina aculeata.
Virgulina subsquamosa.
Bolivina robusta.
Uvigerina asperula.
Epistomina elegans.

A very few sponge spicules were the only siliceous remains found.

Station 184 : Gulf of Aden ; depth 1270 metres ; Bigelow and Agassiz trawl samples ; green mud bordering on Globigerina ooze ; mud 89·9% ; organic remains 10·1%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides rubra.
Gl. sacculifera.
Orbulina universa.
Pulleniatina obliquiloculata.
Globorotalia canariensis.
Gl. crassa.
Gl. menardii.
Gl. truncatulinoides.

Pteropoda.

Cavolinia longirostris.

Benthic remains :—

Foraminifera.

Textularia flinti.
T. semialata.
Sigmoilina schlumbergeri.
Robulus sp.
Bulimina pupoides.
Gyroidina soldani.
Chilostomella ovoidea.
Anomalina balthica.
Planulina wuellerstorfi.

This deposit is from the zone of transition from the shallow water green muds to Globigerina ooze. As might be expected, the usual green mud fauna is largely missing. Mollusca are rare and other groups appear to be absent. The number of species of benthic Foraminifera, characteristic of the green mud, is much reduced, and the contained tests are largely those of pelagic species found most commonly in Globigerina ooze. In this particular deposit *Globorotalia menardii* is very abundant, being as common as the species of *Globigerina* taken together. The deposit might almost be referred to as a "*Globorotalia* mud".

There are numerous chitinous tubes of Polychæta in this deposit each with a compacted outer layer of mud. These tubes are so numerous that they must tend to bind the deposit together into a more solid layer than would otherwise be the case.

Station 185 : Gulf of Aden ; depth 2001 metres ; Bigelow and Agassiz trawl samples ; greenish-brown calcareous mud ; mud 90·5% ; organic remains 9·5%.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides conglobata.
Gl. rubra.
Orbulina universa.
Pulleniatina obliquiloculata.
Globorotalia menardii.

Benthic remains :—

Foraminifera.

Rhabdammina abyssorum.
Rh. abyssorum var. *radiata.*
Crithionina pisum var. *hispida.*
Rhizammina indivisa.
Storthosphæra albida.
Saccammina sphærica.
Tholosina bulla.
Hyperammina friabilis.
Reophax bacillaris.
R. nodulosus.
Ammodiscus exsertus.
Am. incertus.
? *Glomospira gordialis.*
Ammolagena clavata.
Haplophragmoides subglobosum.
Cyclammina pauciloculata.
Gaudryina robusta.
Clavulina communis.
Quinqueloculina auberiana.
Q. procera.
Sigmoilina schlumbergeri.
Pyrgo anomala.
P. depressa.
P. serrata.
P. lucernula.
P. murrhina.
Planispirina sphæra.
Trochammina globigeriniformis.
Lenticulina sp.
Planularia ? *albatrossi.*

Nonion umbilicatulum. *Epistomina elegans.*
Gyroidina soldani. *Planulina ariminensis.*

This deposit contains very large numbers of *Rhabdammina abyssorum.* The residue left after washing out the mud consists almost entirely of this species (see Pl. IV, fig. 2). The deposit may be compared with that described by Schmelck (1882, p. 4) from the Arctic Ocean between Spitzbergen and Norway. This deposit, however, appears from the description to be only slightly calcareous and very clayey, being a variety of the grey clay covering the floor of the Arctic Ocean in this region.

Station 188 : Gulf of Aden ; depth 528 metres ; Agassiz trawl samples ; green mud, very poor in animal remains ; mud 97·1% ; organic remains 2·9%.

Chief components.	Frequency.	% coarse material.	% deposit.
Foraminifera	R	1·9	0·1
Corals	R	2·2	0·1
Echinodermata	R	1·2	tr.
Lamellibranchiata	C	11·8	0·3
Gasteropoda	C	18·6	0·5
Pteropoda	A	38·2	1·1
Scaphopoda	VC	12·6	0·4
Pisces	VC	11·9	0·4
Other remains	R	1·6	tr.
		100·0	2·9

Pelagic remains :—

Foraminifera.

Globigerina bulloides. *Orbulina universa.*
Gl. dubia. *Pulleniatina obliquiloculata.*
Globigerinoides conglobata. *Globorotalia canariensis.*
Gl. rubra. *Gl. menardii.*
Gl. sacculifera.

Pteropoda.

Limacina bulimoides. *Clio pyramidata.*
L. inflata. *Diacria quadridentata.*
L. trochiformis. *D. trispinosa.*
Creseis acicula. *Cavolinia longirostris.*
Cr. virgula. *C. uncinata.*
Hyalocylis striata. *Atlanta* sp.
Styliola subula.

Benthic remains :—

Foraminifera.

Rhabdammina abyssorum. *V. variabilis.*
Rhizammina sp. *Clavulina parisiensis.*
Ammolagena clavata. *Massilina arenaria.*
Cribrostomoides bradyi. *Triloculina circularis.*
Ammomarginulina foliacea. *Pyrgo depressa.*
Verneulina triquetra. *Robulus calcar.*

R. iota.
Lenticulina rotulata.
Nodosaria perversa.
Glandulina radicula.
Nonion ? exponens.
Elphidium craticulatum.
Heterostegina suborbicularis.
Bulimina affinis.
B. elongata.
B. pupoides.
B. pyrula.
B. pyrula var. *spinescens.*
Uvigerina asperula.
U. pygmæa.
Ehrenbergina pacifica.

Shells of the Pteropods, *Diacria quadridentata* and *Limacina* spp., are the commonest organic remains in the deposit.

Station 189 : Gulf of Aden ; depth 91 metres ; Priestman grab samples ; sandy green mud ; mud 71·4% ; organic remains 28·6%.

Chief components.	Frequency.	% coarse material.	% deposit.
Foraminifera	R	0·8	0·3
Polyzoa	R	0·6	0·2
Echinodermata	R	0·4	0·1
Crustacea	F	2·8	0·8
Lamellibranchiata	VC	21·9	6·3
Gasteropoda	A	53·6	15·3
Pteropoda	R	1·5	0·4
Scaphopoda	F	1·4	0·4
Pisces	R	0·4	0·1
Other remains	C	16·6	4·7
		100·0	28·6

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides sacculifera.
Orbulina universa.
Globorotalia menardii.

Pteropoda.

Limacina inflata.
Clio pyramidata.
Diacria quadridentata.
Cavolinia longirostris.
C. uncinata.

Benthic remains :—

Foraminifera.

Textularia pseudocarinata.
T. rhomboidalis.
Quinqueloculina sp.
Spiroloculina depressa.
Sp. grateloupi.
Triloculina tricarinata.
Robulus echinatus.
Robulus sp.
Nodosaria subscalaris.
N. subscalaris var. *paucicostata.*
Vaginulina legumen.
Sigmoidella elegantissima.
Nonion boueanum.
Elphidium crispum.
Operculina granulosa.
Bolivina amygdalæformis.
Rotalia papillosa.
Cancris auriculus.
Amphistegina radiata.
Cibicides lobatulus.

None of the species of Foraminifera and Pteropoda are common. The Pteropoda and many of the benthic Foraminifera are worn or broken. Pelagic Foraminifera are very rare. Although a large percentage consists of molluscan remains there are very few intact shells, and these only of the smallest size. For the most part the shell fragments are small, worn and discoloured. This condition of the remains would indicate the presence of a current along the bottom here, removing the finer mud and rolling the calcareous particles about, thus gradually wearing them away. There is a small amount of H_2S in the deposit.

Station 190 : Gulf of Aden ; depth 183 metres ; Priestman grab samples ; green sand and mud ; mud 57·2% ; organic remains 42·8%.

Chief components.	Frequency.	% course material.	% deposit.
Echinodermata	F	5·0	2·2
Lamellibranchiata	A	53·6	22·9
Gasteropoda	VC	21·3	9·1
Pteropoda	VC	12·0	5·1
Scaphopoda	F	3·8	1·6
Pisces	R	1·6	0·7
Other remains	R	2·7	1·2
		100·0	42·8

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides rubra.
Globigerinella æquilateralis.
Orbulina universa.
Candeina nitida.
Globorotalia canariensis.
Gl. menardii.

Pteropoda.

Clio pyramidata.
Diacria quadridentata.
Cavolinia longirostris.
Cavolinia uncinata.
Atlanta sp.

Benthic remains :—

Foraminifera.

Textularia agglutinans.
T. pseudocarinata.
Clavulina tricarinata.
Spiroloculina depressa.
Sigmoilina schlumbergeri.
Triloculina tricarinata.
Robulus acutauricularis.
Robulus sp.
Nodosaria scalaris.
Saracenaria italica.
Nonion boueanum.
Operculina granulosa.
Bulimina ovata.
B. pagoda.
Bolivina beyrichi.
B. compacta.
B. robusta.
Uvigerina pygmæa.
Valvulineria allomorphinoides.
Rotalia papillosa.
Cancris auriculus.
Cibicides lobatulus.

This deposit contains many Pteropod shells and borders on a Pteropod ooze. Corals and Polychæta are absent. Valves of *Venus torresiana* are abundant (see Pl. II, fig. 1).

Station 191 : Gulf of Aden ; depth 274 metres ; Priestman grab samples ; green mud ; mud 98·0% ; organic remains 2·0%.

Chief components.	Frequency.	% coarse material.	% deposit.
Echinodermata	F	2·5	0·1
Crustacea	R	0·3	tr.
Lamellibranchiata	A	69·9	1·4
Gasteropoda	F	11·2	0·2
Pteropoda	C	10·3	0·2
Scaphopoda	F	3·8	0·1
Pisces	R	1·1	tr.
Other remains	R	0·9	tr.
		100·0	2·0

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides conglobata.
Gl. rubra.
Orbulina universa.
Pulleniatina obliquiloculata.
Globorotalia canariensis.
Gl. menardii.

Pteropoda.

Limacina bulimoides.
L. inflata.
L. trochiformis.
Creseis acicula.
Cr. virgula.
Hyalocylis striata.
Clio pyramidata.
Diacria quadridentata.
Cavolinia longirostris.
C. uncinata.
Atlanta sp.

Benthic remains :—

Foraminifera.

Textularia pseudocarinata.
Clavulina tricarinata.
Spiroloculina grateloupi.
Robulus sp.
Nonion boueanum.
N. ? exponens.
Bulimina ovata.
Bulimina pagoda.
B. pyrula.
Uvigerina brunnensis.
U. pygmæa.
Rotalia papillosa.
Chilostomella ovoidea.

Crustacean remains in the above table are chiefly the valves and compartments of various species of Cirripedia. The animal material consists mainly of the valves of *Venus torresiana.*

Station 192 : Gulf of Aden ; depth 366 metres ; Priestman grab sample ; dark green mud ; mud 97·7% ; organic remains 2·3%.

Pelagic remains :—

Globigerina bulloides.
Gl. dubia.
Globigerinella æquilateralis.
Orbulina universa.
Pulleniatina obliquiloculata.
Candeina nitida.
Globorotalia canariensis.
Gl. menardii.

Pteropoda.

Limacina inflata.
L. trochiformis.
Creseis acicula.
Cr. virgula.
Hyalocylis striata.
Clio pyramidata.
Atlanta sp.

Benthic remains :—

Foraminifera.

Reophax sp.
Textularia semialata
Triloculina trigonula.
Nonion boueanum.
Bulimina ovata.
Bulimina pyrula.
B. pyrula var. *spinescens.*
Uvigerina brunnensis.
U. pygmæa.
Cancris auriculus.

Gasteropoda.

Ranella sp.
Pleurotoma sp.

Lamellibranchiata.

Amussium sp.
Venus torresiana.

Valves of *Venus torresiana* are frequent. Small fæcal pellets are common. Pteropod shells form about 80–85% of the coarse material, *i. e.* 1·8–1·9% of the deposit, but there is insufficient sifted material available to determine the proportions more accurately.

Station 193 : Gulf of Aden ; depth 1061 metres ; Agassiz trawl sample only ; grey-green mud ; mud 58·3% ; organic remains 41·7%.

This is a sifted trawl sample consisting of clinkers and large bivalves containing mud. The above percentages are based on this contained mud. It is possible that the mud in these shells is not representative of the deposit, as they may be filled by the finest mud drifting into them through the small space between the half-open valves. The deposit might be described as Globigerina mud as it approaches a Globigerina ooze.

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides rubra.
Gl. sacculifera.
Orbulina universa.
Pulleniatina obliquiloculata.
Globorotalia canariensis.
Gl. menardii.

Benthic remains :—

Foraminifera.

Spiroplectammina milletti.
Clavulina communis.
Spiroloculina grateloupi.
Sigmoilina schlumbergeri.
Robulus sp.
Dentalina filiformis.
Vaginulina legumen.
Nonion umbilicatulum.
Bulimina ovata.
Bulimina pyrula.
Uvigerina schwageri.
Rotalia papillosa.
Cancris auriculus.
Ehrenbergina pacifica.
Anomalina balthica.
Planulina ariminensis.
Laticarinina pauperata.

Only one Pteropod shell, *Clio pyramidata*, occurred in this deposit. A few Gasteropod shells and *Dentalium* sp. and Crustacean remains occur. Chelæ of a Stomatopod and of *Polycheles* sp. were found.

Station 204 : Red Sea ; depth 110 metres ; Priestman grab sample ; green Globigerina mud ; mud 81·1% ; organic remains and carbonaceous grains 18·9%.

Chief components.	Frequency.	% coarse material.	% deposit.
Foraminifera	A	84·7	16·0
Lamellibranchiata	C	11·7	2·2
Gasteropoda	R	1·3	0·2
Pteropoda	R	1·5	0·4
Other remains	R	0·8	0·1
		100·0	18·9

Pelagic remains :—

Foraminifera.

Globigerina bulloides.
Orbulina universa.
Pulleniatina obliquiloculata.
Globorotalia canariensis.
Gl. menardii.

Pteropoda.

Limacina bulimoides.
L. inflata.
L. trochiformis.
Creseis acicula.
Cr. virgula.
Hyalocylis striata.
Clio pyramidata.
Diacria quadridentata.
D. trispinosa.
Cavolinia inflexa.
C. longirostris.
Atlanta sp.

Benthic remains :—

Foraminifera.

Ammobaculites calcareum.
Textularia sagittula var. *atrata.*
Clavulina tricarinata.
Planularia tricarinella.
Polymorphina ? complexa.
Nonion boueanum.
Bulimina pagoda.
Uvigerina aculeata.
U. pygmæa.

Fragments of the Gasteropods *Ranella* and *Rostellaria* and of the Scaphopod *Cadulus* are recognizable. Larval *Triforis* shells are very common. There is much organic matter in this deposit which, with the green mineral grains, gives the deposit its colour.

Station 206 : Red Sea ; depth 256 metres ; Priestman grab samples ; green Pteropod ooze ; mud 24·7% ; organic remains 75·3%.

Chief components.	Frequency.	% coarse material.	% deposit.
Foraminifera	A	..	62·1
Echinodermata	C	6·6	0·9
Lamellibranchiata	R	3·1	0·4
Gasteropoda	F	6·7	0·9
Pteropoda	A	60·5	8·0
Pisces	C	6·4	0·8
Other remains	F	16·7	2·2
		100·0	75·3

Pelagic remains :—

Foraminifera.

Globigerina bulloides. *Orbulina universa.*
Gl. dubia.

Pteropoda.

Limacina helicina. *Clio pyramidata.*
L. inflata. *Diacria quadridentata.*
Creseis acicula. *Cavolinia globulosa.*
Cr. virgula. *C. longirostris.*
Hyalocylis striata. *Atlanta* sp.

Benthic remains :—

Foraminifera.

Textularia sp. *Rotalia papillosa.*
Bolivina amygdalæformis.

The large percentage of " Foraminifera " in the above table is composed mainly of Foraminifera. Some primordial shells of Pteropoda and fæcal pellets are, however, included in this amount as they are not easily separated.

Almost all the groups that form calcareous skeletons are present in this deposit, but only those in the above table are present in sufficient quantity to influence the nature of the deposit.

Station 207 : Red Sea ; depth 375 metres ; Priestman grab samples ; green Pteropod ooze ; mud 65·7% ; fine organic remains 22·0% ; coarse organic remains 12·3%

Chief components.	Frequency.	% coarse material.	% deposit.
(Foraminifera)	(C)		(11·0)
Echinodermata	VC	12·8	1·6
Gasteropoda	F	6·3	0·8
Pteropoda	A	65·4	8·1
Pisces	VC	10·3	1·2
Other remains	R	5·2	0·6
		100·0	12·3

Pelagic remains :—

Foraminifera.

Globigerina bulloides. *Globigerina dubia.*

Pteropoda.

Limacina inflata. *Clio pyramidata.*
L. trochiformis. *Diacria quadridentata.*
Creseis acicula. *Cavolinia longirostris.*
Cr. virgula. *C. uncinata.*
Hyalocylis striata.

The fine organic material (22·0%) consists, approximately, half of Pteropod fragments and half of Foraminifera. Hence the total Pteropod part of the deposit is in the region of 19·1%.

This deposit is the most typical Pteropod ooze found by the expedition (see Pl. III, fig. 1).

Station 209 : Red Sea ; depth 366 metres ; coarse dredge sample only ; the deposit appears to be greenish-brown mud with rock.

Pelagic remains :—

Globigerina bulloides was the only pelagic Foraminiferan found.

Pteropoda.

Limacina inflata.	*Diacria quadridentata.*
Creseis acicula.	*Cavolinia globulosa.*
Cr. virgula.	*C. longirostris.*
Hyalocylis striata.	*C. uncinata.*
Clio pyramidata.	*Atlanta* sp.

Benthic remains :—

Only one Foraminiferan, *Rhabdammina abyssorum*, was found.

Corals.

Caryophyllia sp.	*Rhizotrochus* sp.
Flabellum sp.	

Gasteropoda.

Conus sp.	*Solarium* sp.

Fish otoliths and Echinoderm remains occur. A large part of the material preserved consists of unidentifiable calcareous rubble and rock fragments.

The following stations were carried out from the motor-boat :

Motor-boat Station I (*b*) : Red Sea ; depth 29 metres ; sand, shell and coral bottom.

The deposit is a fine sand containing fragments of most shallow-water calcareous organisms. *Alveolinella boscii* and *Ammodiscus* sp. occur among the Foraminifera present.

Motor-boat Station I (*d*) : Red Sea ; depth 26 metres ; calcareous sand.

The deposit is similar to the proceeding. Species of *Textularia* and *Robulus* are present. A few Ostracod valves occur and stray specimens of *Cavolinia longirostris* and *C. tridentata.*

Motor-boat Station II (*a*) : South Arabian Coast ; depth 11 metres ; dredge sample ; calcareous shell sand.

Large shell fragments are common. Pteropoda are rare, only *Creseis acicula* being found. The following Foraminifera occur :—

Quinqueloculina sp.	*Sorites marginalis.*
Elphidium sp.	*Peneroplis pertusus.*

Motor-boat Station II (*c*) : South Arabian Coast ; depth 29 metres ; dredge sample ; calcareous sand.

This sample is similar to the preceding, but slightly coarser. *Bolivina* sp. and *Peneroplis pertusus* were the only Foraminifera found. Fragments of Serpulid tubes and of *Balanus* spp. are present.

III. DISTRIBUTION OF THE DEPOSIT TYPES.

1. Topography.

In descriptions of the bottom configuration of the Arabian Sea various names have been proposed for the several deep areas or basins. In the present report I have adopted as a basis those proposed by Wüst (1936). He divides the Arabian Sea into two basins, a North-eastern "Arabian Basin" and a South-western "Somali Basin", separated by the Carlsberg Ridge. In the light of present knowledge of the area this subdivision of the sea-bed is insufficient. First, the discovery of the Murray Ridge parallel to the South Arabian Coast has disclosed a narrow, discontinuous deep area lying along this coast, continuous with a somewhat shallow basin at the mouth of the Gulf of Oman. For ease in the description of its deposits I propose to call this the "Oman Basin". Its south-eastern boundaries are the extension northwards of the Carlsberg Ridge, parallel to the Arabian coast, and South Bank, the most southerly of the series of ridges running in a south-westerly direction from Karachi (see Farquharson, 1936, chart ii).

Secondly, soundings have indicated the probable existence of a ridge projecting out from the African coast in lat. 4° N., running East-south-east across the Somali Basin of Wüst, and probably meeting a similar ridge running towards it in a north-westerly direction from the north side of the Saya de Malha Bank. The Somali Basin thus appears to be divided into two, and I propose here to refer to its parts as the North and South Somali Basins.

These basins are shown in Chart II, which is based on tracings of those prepared by Farquharson (1936). The basins are defined by the 1000 and 2000-fm. contours. Two slight alterations have been made in the configuration of the bottom contours as originally drawn by Farquharson. Investigation of the hydrography has shown that a connection is necessary between the North Somali Basin and the Arabian coastal portion of the Oman Basin to account for the occurrence of the bottom-water found there. In Chart II this connection is shown by uniting the closed 2000-fm. contour east of Socotra through the small 2000-fm. patch south of it, to the corresponding contour of the North Somali Basin. There are no known soundings rendering this alternative charting of the contours impossible.

A similar connection is postulated between the Chagos Archipelago and the Carlsberg Ridge, connecting the Arabian Basin and the Indian-Australian Basin. This, again, is not incompatible with our present knowledge of the soundings. The 2000-fm. contour immediately west of Owen Bank may be continued northwards across the two deep gullies to join the closed southern extremity of the same contour in the Arabian Basin. Accordingly this modification has also been made to the chart.

2. Distribution.

Our knowledge of the distribution of the deposits in the Indian Ocean previous to the "John Murray" Expedition is summed up by Murray and Philippi in their chart published in the report on the "Valdivia" deposits and in that published by Murray in the report on the "Sealark" deposits. From the limited records then available they

showed the greater part of the Arabian Sea to be covered by Globigerina ooze, with a patch of red clay in the area now termed the Arabian Basin and one of Radiolarian ooze in the South Somali Basin. A narrow belt of terrigenous muds, which is considerably wider at the northern end of the Arabian Sea, is shown extending round the coasts. Globigerina ooze is shown to extend as a continuous tongue into the Gulf of Aden, and a few isolated patches of Pteropod ooze are shown along the East African coast and in the Red Sea. Coral muds and sands are shown around all the island groups falling within our present area. No attempt was made in these earlier reports to distinguish between those areas covered by pure Globigerina ooze and those deeper areas covered by an ooze containing a proportion of red clay and brownish or fawn in colour. In the present report I have endeavoured to make such a distinction. The Globigerina ooze areas have been divided into pure Globigerina ooze (pink on chart) and " transitional " ooze (orange on chart). The latter deposit is usually distinguishable on account of its finer texture, fewer Foraminifera and greater cohesion as compared with pure Globigerina ooze. The deposit is considerably more friable than red clay. It is simply a mixture of red clay and Globigerina ooze, and its depth distribution lies between those of these two deposits.

In Chart III the distribution of the deposit-types is shown as revised from Murray's charts in the light of recent discoveries in this area. The distribution of each type is briefly described below.

(a) *Brown, green and grey muds.*—These terrigenous deposits (blue on charts) form a narrow belt along the African coast as far north as Ras Hafún. Off the Arabian and Indian coasts they form a much wider belt. This belt is considerably broader off the Arabian coast than was supposed by Murray, but is of less extent than shown by him off the coast of Baluchistan. Off the Arabian coast it extends below the 2000-fm. line and fills part of the Oman Basin. These deposits floor the Gulf of Oman except for a small patch of Pteropod ooze at its western extremity. The bottom of the Gulf of Aden and Red Sea is covered with this deposit except for small patches of other deposits.

(b) *Globigerina ooze.*—Pure Globigerina ooze (pink on charts) occurs, according to Murray, in the deep central trough of the Red Sea. In the Gulf of Aden it is not possible to lay down definite boundaries to this deposit owing to the very irregular contours of the bottom. The three patches shown on the chart are the only areas definitely known ; others, however, may occur in the deep gullies between the ridges, from which we have no material.

In the open sea pure Globigerina ooze forms a belt lying below the muds, and continued along either side of the line of the Laccadive, Maldive and Chagos Archipelagos. A large patch of Globigerina ooze projects along the Carlsberg Ridge in a south-easterly direction and into the North Somali Basin. There may be a small patch separating the North and South Somali Basins. According to Wiseman and Sewell (1937, p. 222), in " the Somali Basin the sea floor is composed of globigerina ooze . . . " In this paper the transitional ooze has not been differentiated from normal Globigerina ooze, and the patch of Radiolarian ooze in the South Somali Basin has been overlooked.

There is a continuous deposit of Globigerina ooze on the bottom south of a line drawn from the south end of the Maldives to about the latitude of Mafia off the African coast. This continuous area is only broken by the coral deposits round the various archipelagos.

(c) *Transitional ooze.*—A large part of the remaining sea-bottom is covered by transitional ooze (orange on chart), intermediate in character between Globigerina ooze and

red clay. This deposit forms a belt round the central red clay areas of the Arabian, North Somali and South Somali Basins, and also covers a large area connecting these three basins to the east of the North Somali Basin. There is probably a similar belt east of the Chagos Archipelago on the edge of the Indian-Australian Basin.

(d) *Red clay.*—This deposit (brown on chart) fills the centres of the three large basins of the Arabian Sea and the Indian-Australian Basin. Its limits are somewhat doubtful in the Arabian Basin owing to the wide expanse of transitional ooze here and the very gradual transition into pure red clay. It is possible that pure red clay occupies a less area than is shown on the chart, as many of the existing records of red clay probably refer to transitional deposits. Taken at their face value these records render the areas of red clay fairly definite in the Arabian and North Somali Basins. In the South Somali Basin, however, such is not the case, and the extent of the red clay has largely to be deduced from two true red clay samples from the western side, several samples of transitional ooze, and the records of Radiolarian ooze used by Murray to determine the area of this latter deposit. Accordingly the boundary of the red clay is here drawn in to include the red clay stations, the Radiolarian ooze, and just to exclude the known areas of transitional ooze. For the rest the 2500-fm. contour has been roughly followed.

(e) *Radiolarian ooze.*—No samples of this deposit (dark brown on chart) were obtained by the expedition, and the area of this deposit has been copied direct from Murray's (1909) chart of the region.

(f) *Pteropod ooze.*—This deposit (red on chart) occurs intermittently along the African coast. Five small areas are shown by Murray along this coast and three more were found by the "John Murray" expedition. (Only seven are shown on the chart, the most southerly shown by Murray being outside the area illustrated.) All these deposits lie along the line of transition from terrigenous mud to Globigerina ooze. It is possible that there is an almost continuous belt of this deposit along this coast. Murray has recorded Pteropod ooze in the Central and Southern Red Sea, surrounded by Globigerina ooze, and at the boundary between the terrigenous mud and Globigerina ooze respectively. The expedition has shown the existence of a further patch to the south of these, just north of the "sill", that separates the Red Sea from the Gulf of Aden. A smaller and rather impure patch of Pteropod ooze was found in the Gulf of Oman. These two latter areas differ from the others in that they are entirely surrounded by terrigenous mud and are not on the edge of the Globigerina ooze. A similar patch is recorded in the "Investigator" station list (Sta. 212) from off the Gulf of Cambay. Sewell (1935*a*, pl. x) shows several patches of this ooze in the Maldive Archipelago.

(g) *"Coral" deposits.*—These (yellow on chart) are copied from Murray with slight alterations, where these appear necessary in the light of recent soundings, which have corrected the contours and so make it probable that the areas of coral deposits should here be curtailed. A small area of coral reefs and sand is situated on the Arabian side of the Straits of Bab el Mandeb. This area has been recorded several times by various survey ships, the soundings being published in the Admiralty "List of Oceanic Depths."

In the chart of the deposits (Chart III) the top of the Carlsberg Ridge has been represented as covered by Globigerina ooze or transitional ooze. It is possible, however, that parts at least of the ridge may be bare of deposits, as both basalt (Sta. 133) and Limestone (Sta. 168) have been obtained by dredging here on the two crossings of the ridge by the

" Mabahiss ". It is also possible that the summits and troughs of the great ridge system may be covered by slightly different sediments, *e. g.* Globigerina ooze on the ridges and red clay in the troughs.

3. The Zanzibar Area (Chart IV).

For present purpose the " Zanzibar Area " is taken to include that portion of the Indian Ocean lying between Lat. 3° S. and Lat. 7° S., and bounded to the west by the African coast and to the east by the meridian 41° 4′ E. These boundaries include those stations (116–118) lying to the north of Zanzibar and the outlying station 120, as well as those between Zanzibar, Pemba and the mainland.

In determining the boundaries of the deposits the records of the " Valdivia " and those in the " List of Oceanic Depths " have been drawn upon in addition to the new records obtained by the expedition.

Along the coast there is the usual belt of green and brown terrigenous mud giving place to Globigernia ooze below about 400 fms. (738 m.). In the shallow area of the Zanzibar Channel this mud is replaced by a deposit of sand and gravel formed of the calcareous remains of organisms (shells, coral, coralline algæ, Polyzoa, etc.) and the massive tests of bottom-living Foraminifera. These materials are undoubtedly derived in great part from the coral reefs with which the channel is said to be fringed on either side. Another much smaller sand area occurs on the mainland coast to the west of Pemba Island. At the north end of Zanzibar Island is an area of sand and coral. There is another record of coral south-west of Zanzibar and a third south-east of the island on the 7° S. parallel. These records are those of cable-ships and others and hence cannot be relied upon to mean *Madreporarian* coral, though they may do so as coral is common in shallow water in this region. *Lithothamnion* and other coralline algæ are classed as " coral " for purposes of a marine survey of the bottom. A number of records show coral patches to occur in a more or less continuous series along the coast north of Pemba as far as Mombasa. These are apparently part of a more or less continuous reef running along this coast from Zanzibar northwards, and perhaps interrupted at intervals where rivers enter the sea or conditions are otherwise unfavourable for the growth of coral. Fewer records of this coral are available along the mainland coast inside of Pemba and Zanzibar, as this coast has not been worked in the same detail as farther north, where the records lie along the track of a submarine cable. The 'Admiralty Pilot' (p. 321) states that reefs lie along both sides of this channel. Crossland (1902, p. 501) states that coral occurs around all the sand flats off the west coast of Zanzibar Island. Coral was found by the Expedition at Sta. 112 on the African coast and also at an anchorage (Port George) on the Pemba coast. It may therefore be assumed that there is a roughly continuous reef along this part of the coast also.

Terrigenous mud surrounds Pemba Island but only occurs on the seaward side of Zanzibar. To the south of Zanzibar it apparently gives place entirely to sand for a short distance, the sand merging directly into Globigerina ooze in deep water. This phenomenon is probably due to the current, produced by the flow of water into the Zanzibar Channel, sweeping mud away from the region of Ras Kimbiji. The remainder of the Zanzibar Area is covered by Globigerina ooze except for two small patches of Pteropod ooze. As mentioned above, these occur between the terrigenous mud and Globigerina ooze. One lies south-east of Zanzibar in 200 fms. (369 m.) and the other west of Sta. 117 in 400 fms. (738 m.).

Globigerina ooze extends in an impure form, mixed with terrigenous mud, into the deep-water channel west of Pemba Island. It is of interest to note that the area of Globigerina ooze does not correspond exactly with the contours of the channel as outlined by the 400-fm. line. It lies throughout somewhat to the westward and extends in one place above 200 fms. On its eastern side it gives place to terrigenous mud in the deep part of the channel. At its northern extremity this tongue of Globigerina mud, as it has now become, lies entirely to the westward of the 400-fm. contour and extends into shallow water, where it merges with the sand-shell area in about 200 fms.

According to the 'Pilot' (p. 369), the current sets constantly to the northward in the northern part of the Pemba Channel. It is a branch of the main northerly current which is divided by Ras Upembe, the southernmost point of Pemba Island. This northerly current is itself part of the south equatorial current, deflected northwards near the coast. The current is said to follow the axis of the channel. This is apparently the agent transporting the Globigerina ooze into the Pemba Channel. In the northern part of the channel this current is sometimes overcome by the flood setting southward near the Pemba coast. This counter-current may be sufficient to force the northerly stream to the westward of its course, and to slow it up so that it drops its load here to the westward of the deep part of the channel. At the same time the southerly current would itself lose speed, which probably accounts in part for the large deposit of mud on the west side of Pemba Island. Difficulty in getting the trawl on the bottom was experienced at two stations, 121 and 124, in the channel between Pemba Island and Zanzibar Island, the wire streaming out at an angle of 45° to the horizontal. This appeared to be due to a considerable current flowing in a north-north-westerly direction through the channel between the islands at a depth of about 750 m., *i.e.* near the bottom. Doubtless this current also helps to carry the components of Globigerina ooze into the Pemba Channel.

Alternatively, the region being south of the equator, the currents tend to swing to the left owing to the spin of the earth, and this may be the reason for the deposition of Globigerina ooze to the westward of the deep part of the channel.

IV. BIOLOGICAL COMPOSITION OF THE DIFFERENT TYPES OF DEPOSIT.

1. General.

The biological components of the deep-water marine deposits collected consist mainly of the remains of Mollusca, Echinodermata and Foraminifera, together with small quantities of the remains of other animals, notably Polyzoa and Fish. Radiolaria and Diatoms are rare. Only the Foraminifera have been identified in any detail. The pelagic species found in the deposits are a true part of the sediment, as only the dead shells are found there. The bottom-living forms that have been identified are in many cases represented by the tests of animals that were living at the time the material was obtained, and thus are not strictly part of the deposit but belong to the fauna. The tests of dead individuals, however, contribute to the deposit, so these "living" Foraminifera have been included among the biological components of the sediments. Many species are locally abundant, and are of considerable importance as components of the sediment both in determining the consistency of the deposit and as a possible source of food for higher animals. The lists

of Foraminifera included in this section are not exhaustive, but are given in order to differentiate the several deposit-types.

The following list indicates the stations from which material of each of the seven deposit-types was obtained :

a. Grey clay and mud.
Stas. 26, 38, 39, 63, 64, 76, 81, 85, 88, 109, 125.

b. Green and brown muds.
Stas. 5, 14–18, 20, 21, 29, 32–35, 50, 54-59, 65, 66, 70, 73, 74, 79, 104–106, 108, 110, 117, 122, 123, 126, 175, 176, 179a, 179b, 180, 183–185, 188, 189, 191–193, 204.

c. Coarse deposits.
Sands: Stas. 24, 27, 53, 80, 89, 103, 112, 113, 178.
Rock: Stas. 42, 209.
Conglomerate: Stas. 6, 45, 72, 111.

d. Globigerina ooze.
Stas. 22, 60, 62, 87, 93, 102, 114, 118–121, 135, 156, 170, 173, 181.

e. Transitional ooze.
Stas. 92, 127, 128, 132, 134, 167.

f. Pteropod ooze.
Stas. 7, 28, 67, 75, 77, 190, 206, 207.

g. Red clay.
Stas. 100, 101, 166.

h. Deposits from the Maldive Archipelago.
Stas. 137, 139, 141, 142a, 142b, 143–145, 147, 149, 151, 152, 157–161, 163–165.

2. Biological Composition of the Deposits.

(a) *Grey Mud and Clay.*

With the exception of two samples, one of mud and one of clay, from the Zanzibar region, all the materials come from the coastal region stretching from the Gulf of Aden to Karachi and down the west coast of India as far as Bombay. In this area seven samples of grey mud and three of grey clay were collected. The grey muds for the most part occur in deep water, ranging, with the exception of the sample from off Zanzibar in 640 m., from 1687 m. to 3556 m. The average depth is 3135 m. The grey clays vary in depth from 274 m. to 1703 m., the average depth being 867 m. The actual percentage of animal remains in the two deposits is very similar, averaging about 6·3% by weight of the deposit for all the samples and varying from 3·7% to 12·7%, with one extreme case of a grey mud in which no remains were found. The average is slightly higher in the clays than in the muds. The washed clay from Sta. 88 leaves a residue very similar to Pteropod ooze, being composed mainly of Pteropod shells. As, however, these only form 0·6% of the deposit (but 33·3% of the animal remains), the deposit cannot be classed as a Pteropod ooze. A typical sample of the animal remains present in grey mud is shown on Pl. I, fig. 1.

The two types of deposit are difficult to separate, the chief difference being the greater cohesive power of the clay as compared with the mud and the smaller number of species whose remains occur in the clay. The following comparative lists show the paucity of species in the grey clay as contrasted with the grey mud :

	Grey mud.	Grey clay.
Pelagic remains :—		
Foraminifera.		
	Globigerina bulloides.	*Globigerina bulloides.*
	Gl. dubia.	*Gl. dubia.*
	Globigerinoides conglobata.	*Globigerinoides rubra.*
	Gl. rubra.	*Gl. sacculifera.*
	Gl. sacculifera.	*Orbulina universa.*
	Globigerinella æquilateralis.	*Globorotalia menardii.*
	Orbulina universa.	
	Pulleniatina obliquiloculata.	
	Globorotalia menardii.	
Pteropoda.		
	Limacina inflata.	*Limacina inflata.*
	Clio pyramidata.	*Creseis acicula.*
	Cuvierina columnella.	*Cr. virgula.*
	Diacria quadridentata.	*Hyalocylis striata.*
	D. trispinosa.	*Diacria quadridentata.*
	Cavolinia longirostris.	*Cavolinia longirostris.*
	Atlanta sp.	*C. uncinata.*
		Atlanta sp.
Other remains.		
	Otoliths, scales.	Fish vertebræ.
	Coscinodiscus sp.	
	Radiolaria, incl. *Lithocircus* sp.	
Benthic remains :—		
Foraminifera.		
	Rhabdammina abyssorum.	*Quinqueloculina* sp.
	Rh. discreta.	*Triloculina* sp.
	Rh. linearis.	*Robulus acutauricularis.*
	Crithionina pisum.	*Bulimina elongata.*
	Cr. pisum var. *hispida.*	*B. ovata.*
	**Marsipella cylindrica.*	*B. pyrula.*
	Storthosphæra albida.	*Uvigerina bifurcata.*
	**Pilulina jeffreysi.*	*U. pygmæa.*
	**Hyperammina elongata.*	
	H. friabilis.	
	**H. lævigata.*	
	**Reophax pilulifer.*	
	**Hormosina carpenteri.*	
	**H. globulifera.*	
	Haplophragmoides subglobosum.	
	**Clavulina communis* var. *nodulosa.*	
	Pyrgo depressa.	

* These species were found in grey mud only.

	Grey mud.	Grey clay.
P. murrhina.		
**Lenticulina reniformis.*		
Amphisorus hemprichi.		
Nonion umbilicatulum.		
Bulimina aculeata.		
B. pyrula.		
Gyroidina soldani.		
Rotalia beccarii.		
Epistomina elegans.		
Planulina wuellerstorfi.		
Cibicides lobatulus.		
Other remains.		
Polychæt, Echinoderm, Gasteropod, Lamellibranch, Scaphopod fragments.		Small Gasteropoda. Small Lamellibranchiata.
Ostracod valves.		
Poriferan spicules.		

NOTE.—In the above list the Foraminifera from Sta. 125 (grey clay from off Zanzibar) are omitted.

It is noticeable that the pelagic remains are very similar in both grey muds and clays. This is to be expected, as the pelagic fauna is not affected by the type of bottom. The difference between the two types of deposit is shown somewhat strikingly by the microfauna of the bottom. Grey clay supports an extremely small number of animals restricted to very few species, and many groups are entirely lacking in the material examined. The less clayey muds, on the other hand, support quite a rich Foraminiferal fauna, and representatives of most of the bottom-living groups of organisms are present.

The grey muds appear to be mixtures of grey clay (probably of terrigenous origin and a shallow-water deposit), with either green or brown terrigenous mud or Globigerina ooze. The former type is shown by the shallow-water muds from 640 m. off Zanzibar and 1687 m. off Bombay. The rest, from depths from 2156 to 3556 m., are evidently on the borders of the Globigerina ooze and for the most part are grey or fawn-white in colour. The Foraminiferal fauna of the deeper samples, however, shows only a few of the forms typical of Globigerina ooze. Many more arenaceous forms are present, and the fauna is quite distinct from either that of Globigerina ooze or green mud.

The grey mud from Sta. 109 (640 m.) and grey clay from Sta. 125 (805 m.) off Zanzibar are strikingly different from the other deposits of this type as regards their organic remains. The grey mud is almost devoid of organic remains, only three species of Foraminifera being identified, whereas at Sta. 125 the grey clay yielded a large number of species. This is exactly opposite to what we find in the northern Arabian sea, where the muds all contain remains of more species than the clays.

From a comparison of the faunas, the deposit at Sta. 125 resembles a grey or even a green mud far more than it does the clays from the northern Arabian Sea. Similarly the mud from Sta. 109 compares readily with the clays from this area. The numbers of

species of Foraminifera and Pteropoda present in these two samples are compared with normal grey mud and clay in Table II :—

Table II.

Station and deposit.	Pelagic Foraminifera.	Benthic Foraminifera.	Pteropoda.
109; grey mud	..	3	3
125; grey clay	8	39	2
Normal grey mud	9	28	6
Normal grey clay	6	8	7

Here, however, the resemblances end. The deposit at Sta. 109 is a typical mud from shallow water and is not more coherent than other inshore grey muds. That from Sta. 125, despite its faunal resemblances to a mud, is a very coherent, plastic deposit—an unmistakable clay.

These differences in the faunas of these deposits would indicate that some other factor, and not the character of the deposit alone, is responsible for the poor fauna met with in the grey clay area of the northern region of the Arabian Sea. This factor is apparently hydrological. It will be shown later (p. 148) that the water in the Gulf of Oman is very poorly oxygenated down to a depth of about 1500 m., and that the water flowing out of the Persian Gulf is highly saline. The combination of these two factors appears to kill off any animals brought into the Gulf by inflowing Arabian Sea water and permits only a limited production of life within its own confines. Where this highly saline water comes into contact with the bottom on the Arabian coast about Ras al Hadd there is a very great destruction of life, so that a large amount of organic matter accumulates in the mud. The decay of this material apparently brings about anaërobic conditions, and the bacterial production of sulphuretted hydrogen in the mud. The area about Ras al Hadd is thus rendered azoic. Further eastward there is no production of sulphuretted hydrogen in the mud, which here contains less organic matter, but the oxygen content of the water is probably so low that life cannot persist. Thus a large area of the sea-bed in the mouth of the Gulf of Oman and in the northern part of the Arabian Sea is rendered practically azoic.

(b) *Green and Brown Muds.*

Fifty samples of terrigenous mud were collected. With one exception they range in colour from dark brown to dark green. The exception (from Sta. 5) is a very light brown or yellow mud. Blue mud was not met with in the north-west area of the Indian Ocean, though the " Valdivia " obtained it three times on the East African coast and once in the Bay of Bengal (Murray and Philippi, 1908, p. 153). The range in depth at which these muds occur is considerable, samples being collected from 91 m. and 2072 m. The former is transitional to the sandy shallow-water deposits and the latter approximates to a Globigerina ooze. The average depth of the deposit is 793 m. With the exception of seven samples the percentage of animal remains is low, averaging 9·3%. The seven exceptions are tabulated below (Table III), with remarks as to the possible reason for the large amount of animal material present. They are not typical green or brown muds,

TABLE III.

Station	Depth (m.)	% animal remains.	Remarks.
29	2072	34·5	Transitional to Globigerina ooze ;
35	441	31·4	mainly Foraminifera.
50	1738	32·4	Sandy mud.
73	91	64·5	Very sandy mud.
110	329	62·1	Transitional to Globigerina ooze.
176	695	55·4	Largely fæcal pellets.
193	1061	41·7	A partially sifted deposit.

The more usual percentages are shown in Table IV. These have not been selected, but taken half from the top and half from the bottom of a list arranged in order of stations. In the normal muds the percentage of animal remains varies from 1·9% to 24·1%, usually between 6% and 14%. The graph (Fig. 1) shows the average percentage of animal remains per 100 m. depth. It is seen that the shallow-water deposits contain a rather high percentage, nearly 25%, which falls off very rapidly on descending into deeper water.

TABLE IV.

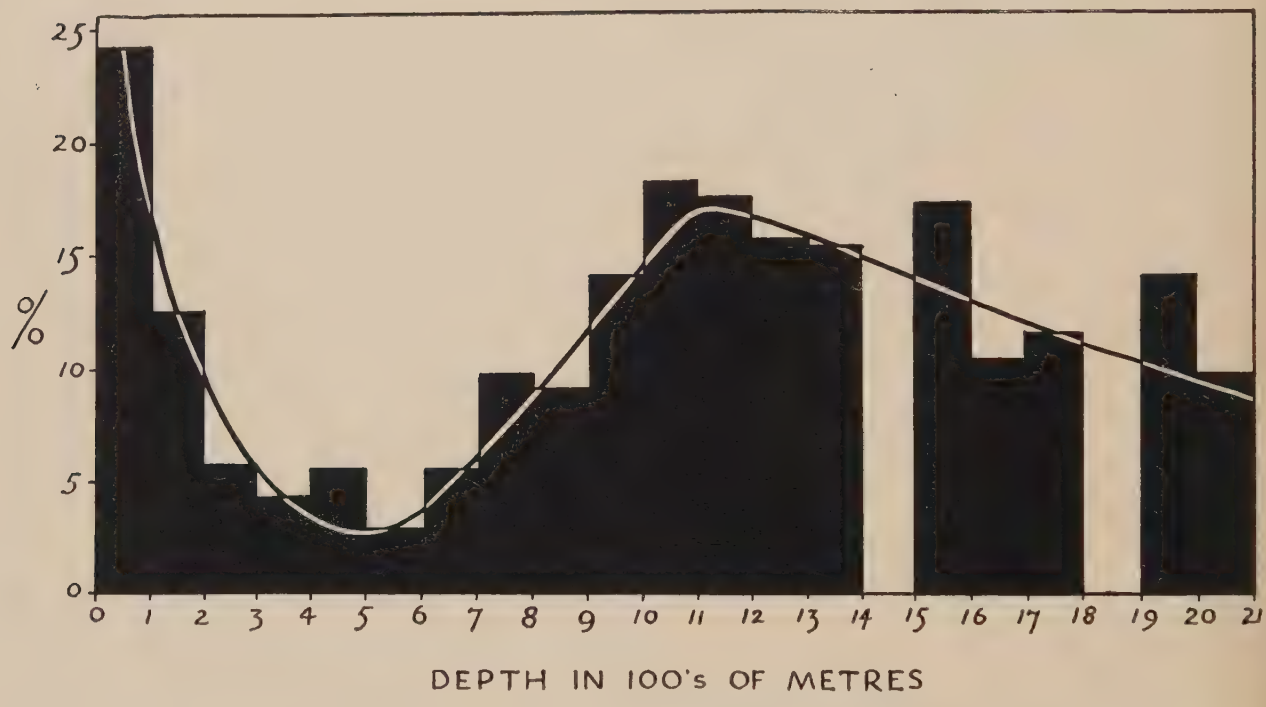
Station.	Depth (m.)	% animal remains.
5	938	14·1
14	1764	11·3
15	1053	16·8
15–16	..	9·6
16	186	11·6
179a	310	6·7
179b	275	7·8
180	397	7·3
183	1105	6·6
184	1270	10·1
	Average	10·2

A minimum percentage of animal remains is found between 500 m. and 600 m., below which depth the percentage rises again. This minimum probably marks the lower limit of the shallow-water or littoral forms and the beginning of the continental slope fauna, the two faunas exhibiting an "overlap" region in which neither is particularly abundant. Below 600 m. the amount of remains present increases considerably, to reach a maximum in about 1100–1200 m. Here the remains consist mainly of continental slope forms, plus gradually increasing amounts of pelagic material.

The shape of the curve must be influenced to a considerable degree by the amount of deposition of sediments derived from the land. In shallow water there is an abundant fauna leaving calcareous remains and, owing to constant movement of the water, little sedimentation of fine material. The percentage of animal remains in the deposit is therefore high. In rather deeper water the terrigenous material begins to be deposited and the percentage of remains falls correspondingly. This presumably goes on until about 500 m., at

which depth the maximum amount of mud is being deposited and so the percentage of remains is at a minimum. This zone of maximum sedimentation has been called by Murray the " mudline ", and is considered by him to be the richest feeding-ground of the ocean. The depth of the " mudline " naturally varies with local conditions ; 500 m. is only an average figure for the whole of the Arabian Sea. In still deeper water less and less mud is deposited, and the percentage of remains increases again to a maximum in 1100 m. This is, of course, assuming that the density of the fauna is the same throughout the depth-range (1200 m.) under consideration.

Actually both factors, namely the degree of sedimentation and the density of the fauna, probably combine to determine the shape of the curve. As is shown later (Text-fig. 2, p. 120), and as Alcock (1890, p. 426) has shown, there is a region in which life is somewhat scarce.



TEXT-FIG. 1.—Percentage of animal remains in green mud at different depths.

The position of this region seems to vary in different areas. The " Murray " Expedition records point to a zone between about 80 m. and 150 m. as the poor area in the Arabian Sea ; Alcock gives 37–74 m. for the corresponding zone off the Ganjam coast. Thus the small amount of animal remains present in the deposit in about 500 m. may be said to be due to the poorness of the fauna in the zone above (the remains will tend to be carried into deeper water), and to the greater deposition of mud in this depth compared with shallower or deeper water.

From 1200 m. down to 2000 m. there is a fairly steady decrease in the amount of animal material and a corresponding increase in the fineness of the deposit. Finally at this lower depth the muds mostly pass into Globigerina ooze and the percentage of animal material soars again, but now consists of a high percentage of pelagic remains and very few benthic forms.

Under different conditions the depth at which the change-over from one type of

deposit to the next occurs naturally varies, and so some samples of mud contain amounts of remains abnormal for the depth. A number of such (high) values have been listed above (Table III, p. 113); exceptionally low values also occur. In averaging the percentage over each 100 m. these abnormally high values have been omitted. Similar considerations probably account for the high average values met with from 1500–1600 m. and 1900–2000 m., as shown in Text-fig. 1.

There is a further possible explanation of the minimum value for the amount of animal material at about 600 m., namely the destructive activity of the mud-feeding organisms, which may destroy large numbers of the contained small animals, chiefly Foraminifera.

The biological components of the mud fall into two groups—(i) the remains of pelagic organisms and (ii) those of benthic animals. The former are somewhat limited in number of species, probably owing to the few species of pelagic animals, in comparison with benthic animals, that leave calcareous or other resistant remains, and also to the smaller number of pelagic species in inshore waters as compared with the open ocean. The actual percentage of pelagic remains, though not calculated separately, is small, owing to swamping by the large numbers of benthic organisms, especially Foraminifera, which abound in the terrigenous muds. The following is a list of the pelagic organisms present in the muds examined :—

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides conglobata.
Gl. rubra.
Gl. sacculifera.
Globigerinella æquilateralis.
Hastigerina pelagica.
Orbulina universa.
Pulleniatina obliquiloculata.
Sphæroidinella dehiscens.
Candeina nitida.
Globorotalia canariensis.
Gl. crassa.
Gl. menardii.
Gl. tumida.

Pteropoda.

Peraclis bispinosa.
Limacina bulimoides.
L. inflata.
L. trochiformis.
Creseis acicula.
Cr. virgula.
Hyalocylis striata.
Styliola subula.
Clio pyramidata.
Cuvierina columnella.
Diacria quadridentata.
D. trispinosa.
Cavolina inflexa.
C. longirostris.
C. tridentata.
C. uncinata.
Atlanta sp.

Other remains : Otoliths, scales and vertebræ of fish.

The pelagic components are thus similar to those of other sediments, but are richer in species, especially of Pteropoda. This abundance of Pteropoda is to be expected as the range of Pteropod ooze falls within that of the muds and in places, e. g. off the African coast and at the southern end of the Red Sea, the green muds grade into Pteropod deposits.

As already mentioned, the number of species of benthic Foraminifera is high in the green and brown muds : 192 species and varieties have been identified in these deposits : of these very few are of frequent occurrence, while a very large number were found only in three or less of the fifty samples examined. Only eighteen species occurred in five or more

samples. The following list indicates the species found and the number of times they occurred. *Bulimina pyrula* (12 stations), *Uvigerina pygmæa* (11 stations), and *Cancris auriculus* (10 stations) occur most frequently.

TABLE V.

Species.	Number of occurrences.	Species.	Number of occurences.
Rhabdammina abyssorum	3	**Verneulina scabra*	1
Rh. abyssorum var. *radiata*	1	*V. triquetra*	1
Crithionina pisum var. *hispida*	2	**V. variabilis*	1
Rhizammina indivisa	1	*Gaudryina baccata*	1
Storthosphæra albida	2	**G. pseudo-filiformis*	1
Saccammina sphærica	1	**G. robusta*	1
Pilulina jeffreysi	2	**Valvulina conica*	1
**Tholosina bulla*	2	* *V. fusca*	1
Hyperammina friabilis	1	*Clavulina angularis*	1
**Dendrophrya ramosa*	1	*Cl. communis*	6
**Reophax agglutinans*	1	*Cl. pacifica*	1
**R. bacillaris*	1	*Cl. parisiensis*	3
**R. bilocularis*	1	*Cl. tricarinata*	2
**R. guttifer*	1	**Quinqueloculina auberiana*	1
**R. nodulosus*	2	**Q. procera*	1
Haplostiche dubia	2	**Massilina arenaria*	3
**Ammodiscus exsertus*	1	*M. australis*	1
**Am. incertus*	2	*Spiroloculina depressa*	4
**Ammodiscoides turbinatus*	1	*Sp. grateloupi*	3
**Tolypammina vagans*	2	**Sigmoilina edwardsi*	1
**Ammolagena clavata*	4	*S. schlumbergeri*	8
Haplophragmoides subglobosum	2	**Triloculina circularis*	1
Cribrostomoides bradyi	1	*Tr. tricarinata*	1
**Ammomarginulina foliacea*	2	*Tr. trigonula*	1
**Cyclammina pauciloculata*	1	*Pyrgo anomala*	1
Ammobaculites calcareum	3	**P. comata*	2
Spiroplectammina milletti	4	*P. denticulata*	1
Textularia agglutinans	2	*P. depressa*	4
T. conica	2	*P. lucernula*	1
**T. goesi*	1	*P. murrhina*	5
T. gramen	3	*P. sarsi*	2
T. pseudocarinata	3	*P. serrata*	1
T. rhomboidalis	1	*P. vespertilio*	1
T. sagittula	4	*Biloculinella globula*	2
T. sagittula var. *atrata*	2	*Cornuspira carinata*	1
T. sagittula var. *fistulosa*	1	**Ophthalmidium inconstans*	1
**T. semialata*	3	*Planispirina sphæra*	2
Verneulina propinqua	1	**Trochammina globigeriniformis*	1

* These species were found only in terrigenous mud.

Species.	Number of occurrences.
**Tr. squamata*	1
Placopsilina cenomana	1
Robulus calcar	3
R. costatus	2
R. costatus var. multicostatus	2
**R. echinatus*	2
R. gibbus	1
**R. iota*	4
**R. limbosus*	1
R. orbicularis	2
**Lenticulina calcarata*	1
L. rotulata	4
**Planularia ? albatrossi*	1
**Pl. tricarinella*	2
Marginulina glabra	1
**Dentalina communis*	1
**D. consobrina*	1
D. consobrina var. *emaciata*	1
D. filiformis	1
**Nodosaria flinti*	2
N. pauciloculata	1
**N. perversa*	1
N. pyrula	1
**N. radicula*	1
N. scalaris	1
**N. soluta*	1
N. subscalaris	2
N. subscalaris var. *paucicostata*	1
N. vertebralis	1
Saracenaria italica	1
Vaginulina legumen	2
V. linearis	1
**V. wetherellii*	1
**Frondicularia plicata*	1
**Lagena marginata*	2
**Glandulina radicula*	1
Sigmoidella elegantissima	1
**Polymorphina ? complexa*	1
Nonion boueanun	4
**N. exponens*	2
**N. pacificum*	1
**N. pompilioides*	2
N. scaphum	1
N. umbilicatulum	5

Species.	Number of occurrences.
**Nonionella* sp.	1
Elphidium craticulatum	1
El. crispum	3
**El. jenseni*	1
Operculina granulosa	5
Heterostegina depressa	3
H. operculinoides	2
H. suborbicularis	2
Sorites marginalis	1
Amphisorus hemprichi	1
Marginopora vertebralis	1
Bulimina aculeata	4
**B. affinis*	1
**B. elegans*	1
B. elongata	1
B. ovata	9
B. pagoda	2
**B. pupoides*	7
B. pyrula	12
**B. pyrula* var. *spinescens*	2
**B. subornata*	3
**Virgulina squamosa*	1
V. subsquamosa	3
Bolivina amygdalæformis	2
B. beyrichi	2
B. beyrichi var. *alata*	1
B. dilatata	1
**B. pygmœa*	2
B. robusta	1
B. simpsoni	1
Uvigerina aculeata	2
**U. asperula*	2
U. bifurcata	2
U. brunnensis	6
**U. proboscidea*	1
U. pygmœa	11
U. schwageri	4
U. tenuistriata	4
**Siphogenerina bifrons*	1
**S. dimorpha*	1
S. striata var. *curta*	2
**S. virgula*	1
Angulogerina carinata	3
**An. carinata* var. *bradyana*	1

Species.	Number of occurrences.	Species.	Number of occurrences.
**Valvulineria allomorphinoides*	2	**Anomalina balthica*	4
Gyroidina soldani	3	**Planulina ammonoides*	1
Eponides præcinctus	2	*Pl. ariminensis*	5
Rotalia beccarii	1	*Pl. wuellerstorfi*	8
R. calcar	1	*Laticarinina pauperata*	2
R. margaritifera	2	*Cibicides lobatulus*	6
R. papillosa	7	*Planorbulinella larvata*	1
Epistomina elegans	5	*Gypsina globulus*	1
Cancris auriculus	10	*Carpenteria monticularis*	1
Amphistegina radiata	5	*C. proteiformis*	2
Cymbaloporetta bradyi	1	*C. utricularis*	1
Cymbaloporella tabellæformis	1	*Homotrema rubrum*	1
Ehrenbergina pacifica	7	*Sporadotrema cylindricum*	1
Chilostomella ovoidea	4	*Sp. mesentericum*	1
**Sphæroidina bulloides*	1	*Miniacina miniacea*	1

In addition to the above the following were identified :

Crustacea.
- *Balanus* sp.
- *Verruca* sp.

Gasteropoda.
- *Pleurotoma* sp.
- *Ranella* sp.
- *Rostellaria* sp.
- *Triforis* sp. (larval shells).

Scaphopoda.
- *Cadulus* sp.
- *Dentalium* sp.

Lamellibranchiata.
- *Amussium* sp.

Polyzoa.
- *Cellaria* sp.

Cœlenterata.
- *Acropora* sp.
- *Cycloseris* sp.
- *Pachyseris* sp.
- *Tubipora* sp.

Hydrocorallinæ.

Alcyonaria.

All the Cœlenterate remains come from Sta. 126.

It thus appears that the green muds are not well characterized by the presence of any typical series of species of Foraminifera ; it is, however, possible to pick out a number of genera that are represented by many species. These genera are evidently the best suited to this type of deposit and have developed many species here, but they are by no means confined to these deposits, being represented by the same or other species in very different sediments. Of such genera in the above list may be mentioned *Textularia* (8 spp. and 2 varieties), *Pyrgo* (9 spp.), *Robulus* (7 spp. identified, several unidentified), *Nodosaria* (incl. *Dentalina*, 12 spp. and 2 varieties), *Bulimina* (9 spp., 1 variety), *Bolivina* (6 spp., 1 variety) and *Uvigerina* (8 spp.). The family Buliminidæ as a whole appears to favour green or brown muds as a habitat ; many more species of this family were found in this type of deposit than elsewhere. As is to be expected, families of attached forms, like the Rupertiidæ and Homotremidæ, are rare, this type of sediment offering few or no solid objects for attachment. The species of *Carpenteria* (Rupertiidæ), *Homotrema*, *Sporadotrema* and *Miniacina* (Homotremidæ) found elsewhere occurred here only once or twice and

chiefly at Sta. 126 off Zanzibar Island, where the sediment is coarser than is usual for green mud.

Although the majority of the Foraminifera occur infrequently, some may be extraordinarily abundant over small areas, in which they form the bulk of the larger components of the deposit. Two such instances may be cited here. At Sta. 185, in the Gulf of Aden, the residue obtained by sifting the deposit consists almost entirely of the brown tests of *Rhabdammina abyssorum* M. Sars (see Pl. IV, fig. 2). Schmelck (1882, p. 43) records a similar abundance of this species in the Norwegian Sea under the name " Rhabdammina Clay " or " Green Clay ". This deposit was a gritty mud with quartz grains and was only slightly coherent when dry—scarcely a clay. The contained animal remains were Annelid tubes, exclusively *Spirochetopterus* sp., sponge spicules and shells of *Astarte* sp. besides *Rhabdammina*, " . . . which would appear to be comparatively numerous " (*loc. cit.*, p. 44). This composition is very similar to that of the present sample, except that here the mud is finer and with less quartz grains. Flexible worm-tubes and shell fragments are fairly common, and a few other animal remains occur but are largely obscured by the enormous numbers of *Rhabdammina*. Agassiz (1892, p. 11), again, records similar masses of a species of *Rhabdammina*, " closely allied to *R. lineata* ", from off the west coast of tropical America.

The second example is from Sta. 105, off Zanzibar. Here a large part of the residue from the sifted sediment consists of fragments of the branched Foraminiferan *Dendrophrya ramosa* Cushman (see Pl. IV, fig. 1). The deposit is again associated with a large number of fine papery worm-tubes with an adherent outer coating of mud. The probable cause of this great abundance of a bottom species in a small area is referred to elsewhere (p. 156).

Typical samples of the organic remains found in green and brown muds are shown in Pl. I, figs. 2–6, and Pl. II, fig. 1.

At Sta. 55, off Ras al Hadd, the deposit is green mud containing very large numbers of a large round diatom, *Coscinodiscus oculis-iridis* var. *borealis* (Bail.) Cl.* (see Pl. I, figs. 5, 6). This diatom also occurred in the sediments collected at the adjacent stations 56 and 57 but in far fewer numbers. Elsewhere *Coscinodiscus* spp. were absent, or represented by very rare fragments only.

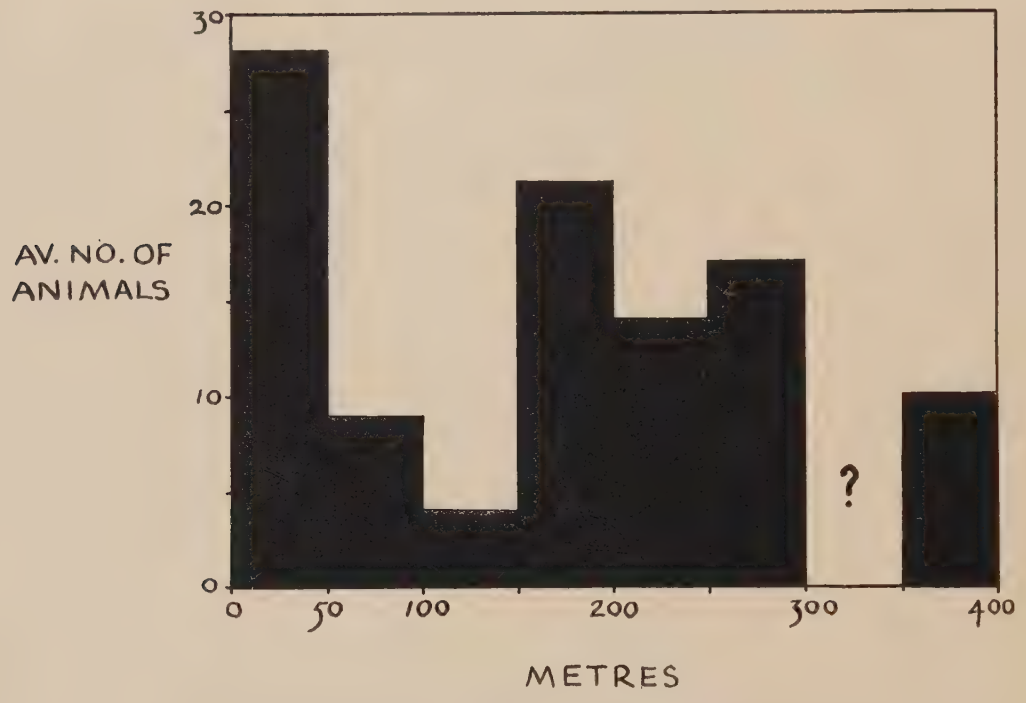
Diatom ooze is well known from the Southern Ocean and from the North Pacific, where large well-defined belts of the deposit occur. It is not common, however, in lower latitudes, and has been recorded from a relatively few isolated areas. One such area is recorded by Murray and Lee (1909, p. 48, and map ii) from off Lima, Peru, and another by Murray and Philippi (1908, chart ii) from the Southern Indian Ocean midway between Madagascar and Kerguelen in about Lat. 38° S. Both these deposits contain *Coscinodiscus* spp. Hanzawa (1935, pp. 37 *et seq.*, pls., I, II) describes a number of Diatom oozes forming isolated patches within the area Lat. 19° 8·5′ N. to 8° 40′ N. and Long. 136° 32·6′ E. to 153° 6·5′ E. These last deposits, however, differ in that the predominating diatom is *Ethmodiscus* sp., a form similar to *Coscinodiscus*, which is here rare or absent. Thus, in the Pacific, the Diatom ooze north of the equator in low latitudes is an *Ethmodiscus* ooze and south of the equator a *Coscinodiscus* ooze, as far as one can tell from the single record known. In the Indian Ocean, however, this is not so. Here there is no northern belt of Diatom ooze, as the sea is bounded by the continent of Asia in quite low latitudes. True Diatom ooze is apparently not developed in the Indian Ocean, but deposits rich in diatoms occur off the eastern point of Arabia and in a few other areas, *e. g.* Sta. 22 in the Gulf of

* I am indebted to Dr. S. Chaffers for this identification.

Aden. This deposit off Ras al Hadd lies in Lat. 22° N., only slightly further north than the *Ethmodiscus* deposits of the Pacific, but this genus is apparently absent. *Ethmodiscus* is not recorded by Hornell and Nayudu (1924, p. 149) or Menon (1931, p. 495) from the coasts of Peninsular India. They, however, found *Coscinodiscus* to be one of the chief components of the Diatom plankton. Apparently, therefore, *Ethmodiscus* is rare in, if not absent from, the northern part of the Indian Ocean, its place being taken by species of *Coscinodiscus*.

(b. i) *The effect of depth upon the fauna on green and brown muds.*—The large number of samples (34) of terrigenous mud collected with the Priestman grab have made it possible to study the effect of depth upon the density of the macro-fauna.

The numbers of animals caught in the grab are summarized in Table VI. The hauls



Text-fig. 2.—Number of animals caught by the Priestman grab.

are arranged in order of depth, and one Lagoon haul (Sta. 137, 46 m.) is included to give an idea of the abundance of life in very shallow water. The total catch of animals at each depth has been divided by the number of hauls, thus giving an average of the numbers caught at each depth. Where a haul was unproductive of life, through the grab jamming or failing to close properly, the haul has been excluded from the averaging. In many cases the figures in the last two columns are only approximate, as the number of specimens obtained was not always recorded. Many records of grab hauls only mention " few ", " several " or " numerous " specimens of a species.

The figures in the column, " Average animals per haul ", represent the number of animals present on or in 0·5 sq. m. of the deposit, the area covered by the Priestman grab.

A sufficient number of results are available to make it possible to graph the relationship between the depth and the density of fauna. The average number of animals collected is plotted against 50 m. intervals of depth (Text-fig. 2).

TABLE VI.

Depth (m.)	Station.	Number of successful hauls.	Total animals.	Average animals per haul.	Average 50 m.
46	137	1	28	28	28
91	73, 90, 178, 189	3	26	9	9
101	103, 151	1	7	7	4
110	204	1	1	1	
113	112	1	?	?	
155	74	1	?	?	21
177	205, 164	1	2	2	
183	190	2	68	34	
193	89	1	12	12	
201	28, 75	2	53+ several	(30)	14
207	104	2	15+ several	(10)	
209	126				
220	113	1	..	..	
238	149	1	4+ several	(6)	
256	206	1	18+ several	(22)	
274	88, 163, 191	4	72+ several	(20)	17
275	179b				
280	105	1	..	..	
310	179a	1	..	..	0
353	114, 165	1	..	..	
366	192	1	10	10	10
375	207	1	16	16	
397	180	1	15	15	
411	77	1	..	..	0
423	150	1	..	..	
805	125	1	..	..	0

Owing to the grab being jammed by rocky material and to indefinite statements of the number of animals caught the graph is based on one result only over the depth range 100–150 m. Similar considerations apply to the range 300–350 m., where of three hauls

one was jammed and two empty of animals, though at one of the stations a haul with the Agassiz trawl brought up a rich fauna. Hence no value, however approximate, can be given for this range. The number of hauls is small. In most 50-m. ranges only two to three hauls were made, so that the above graph can only be taken as a rough approximation. The maximum number of results was six in the range 150–200 m.

A sharp falling off from the number of individuals present in the shallow water of the littoral zone is indicated in the first 100 m. There is a subsequent increase again, reaching a maximum in about 200 m. due to the replacement of the littoral by the Continental Shelf fauna, which reaches its greatest development in about this depth. Below 200 m. there is a steady falling off in the numbers caught at increasing depths. Below 397 m. no animals were caught in depths of 411, 423 and 805 m. in which the grab was used.

As already mentioned (p. 114), the same zonation has been recorded by Alcock (1890, p. 426) off the Ganjam coast. This author distinguishes three zones of life on this coast as follows :

1. 0–14 fms. (0–26 m.).

   Here life is abundant, and hauls may contain several species in large numbers. This zone corresponds to the 0–50 m. section of Text-fig. 2.

2. 20–40 fms. (37–74 m.).

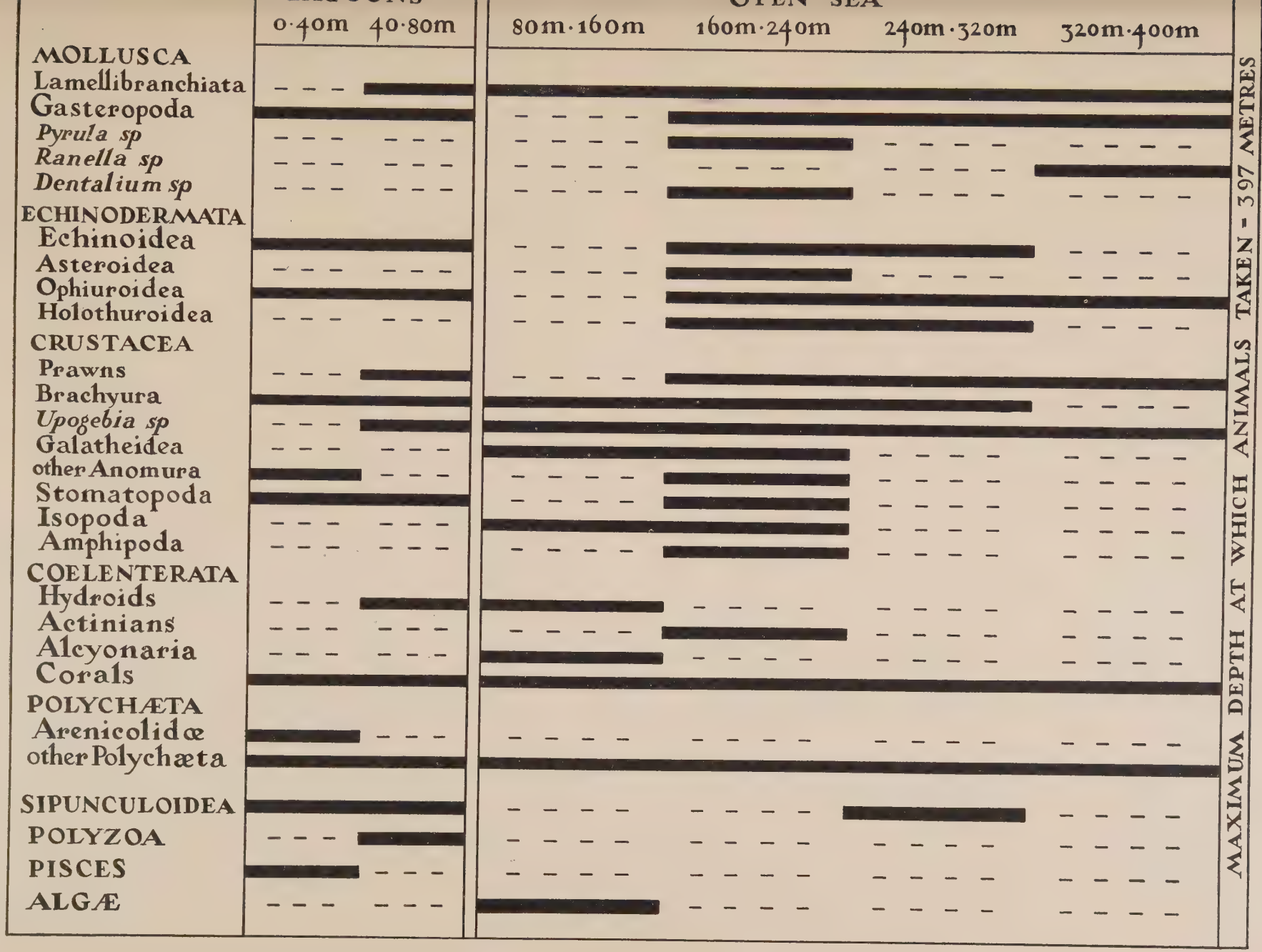
   In this zone the hauls are usually small and most of the species from the previous zone are absent. It corresponds approximately with the region from 100–150 m. on Text-fig. 2.

3. 70–100 fms. (130–185 m.).

   Large and varied hauls were taken in this zone and the forms have a distinct bathybial facies. This zone is the same as that represented on the graph by the peak in 150–200 m.

There is a striking similarity between the form of this graph (Text-fig. 2) of the living animals and Text-fig. 1, in which the percentage of animal remains was plotted against depth. In Text-fig. 1 the minimum percentage of fragments occurs in deeper water, between 500 and 600 m. as against 100–150 m. here. This may reasonably be considered as due to the transport of dead shells and other remains, by current movement, into deeper water. Such transport is probably ineffective below 500 m. The graph of the remains (Text-fig. 1) has a peak at about 1100–1200 m., due to the great deposition of tests of pelagic Foraminifera in these depths. It cannot be correlated with the maximum in 200 m. shown in Text-fig. 2. As already stated this is due to the full development of the Continental Shelf fauna here. It has already been shown (p. 113) that the zone of maximum sedimentation, the " mud-line ", occurs at about 500 m. Apparently the largest number of animals occurs in the upper part of the zone of heavy sedimentation and not where sedimentation is at a maximum.

(b. ii) *The depth range of animals from the green and brown muds taken by the Priestman grab.*—Thirty of the forty Priestman Grab hauls contained living animals. The most frequently occurring organisms were : Polychæta (24 times), Lamellibranchiata and Brachyura (10 times), Ophiuroidea and Porifera (8 times), Prawns and Stomatopoda (6 times). These and the other genera and groups of animals obtained are shown on Text-fig. 3. Those not mentioned above only occurred four times or less. Thus no less than 80% of the successful hauls yielded worms which were far more frequent than other groups ; the next in order of frequency, Lamellibranchiata and Brachyura, both occurred in only one-third of the successful hauls. This is a striking illustration of the widespread



TEXT-FIG. 3.—Depth range of animals obtained in the Priestman grab.

distribution and abundance of the Polychæta, compared with other organisms, in the shallow waters of the Arabian Sea. Only the above-mentioned seven groups appear to be at all uniformly distributed, though others may be common locally.

The depth range of the animals collected is summarized in Text-fig. 3. It is evident from this figure that the lagoons support quite a varied fauna ; sixteen of the twenty-seven groups or genera distinguished in the table were obtained there by the grab. Doubtless others occur, though not obtained by this means. The richest fauna on the Continental shelf is seen to occur about 160–240 m., nineteen groups being collected within this depth range as against eleven or less in the others. This has been seen already in Text-fig. 2 (p. 120) where the average number of animals per haul was plotted against the depth in 50-m. intervals and a maximum was found in 150–200 m. In shallower water (80–160 m.) fewer animals were obtained, whole groups such as Gasteropoda and Echinodermata being unrepresented in the hauls. Below the rich zone, also, the numbers obtained fell off considerably. In the next range, 240–320 m., only eleven groups occurred, and in the deepest of all, 320–400 m., the number was reduced to eight. It is worthy of note that seven of these, Lamellibranchiata, Gasteropoda, Ophiuroidea, Prawns, *Upogebia* sp., Corals and Polychæta, all have a very wide range. The first two and the last two of these were found from 80 m. downwards, and the other three in the next range from 160 m. downwards.

The distribution of the Sipunculoidea is curious : they were found several times in shallow lagoon waters and once in open water at a depth of 274 m., with no indication of their occurrence in shallow open water. It is quite probable that this is due solely to the small number of records (four only).

(c) *Coarser Deposits.*

The remaining terrigenous deposits consists of sands, calcareous conglomerates, and mud with a large amount of rock fragments or calcareous rubble, *i. e.* unidentifiable calcareous material of animal origin. The rock and rubble deposits will be considered separately from the sands. Apart from one sample containing rock fragments from 1415 m. (Sta. 42) and one of calcareous conglomerate from 1167 m. (Sta. 6) all these deposit samples are from comparatively shallow water. The deepest is from 366 m.

(c. i) *The conglomerates.*—Seven samples were obtained containing much coarse rubble and rock fragments. Of these, three (from Stas. 6, 45, and 72) consisted of a calcareous conglomerate formed of fragments of the shells of recent animals cemented together. One (Sta. 111) consisted almost entirely of loose calcareous rubble, and the remaining three (Stas. 42, 67, 209) of limestone fragments, rubble and green mud. Sta. 67 also yielded fragments of serpentinized enstatite peridotite.

The conglomerate contains the remains of a limited fauna. In the material from Sta. 6 the following species of Pteropoda were identified :

Limacina inflata
Creseis acicula.
Cr. virgula.
Hyalocylis striata.
Diacria quadridentata.
Cavolinia longirostris.
Atlanta sp.

A few *Globigerina bulloides* and Gasteropod fragments were present. The rest of the conglomerate consisted of rather small shell fragments, occasional bottom Foraminifera

and Echinoid spines. Most of the remains are those of shallow-water attached animals and Foraminifera.

The green mud from Sta. 209 contains a considerable number of species of Pteropoda, in addition to broken shells of *Conus* and *Solarium* and the solitary corals *Flabellum*, *Rhizotrochus* and *Caryophyllia*. This deposit is near the area of Pteropod ooze at the south end of the Red Sea, which accounts for the presence of so many Pteropoda.

Table VII summarizes the nature of the deposit at these seven stations :

TABLE VII.

Station.	Depth (m.).	Deposit-type.	Chief animal remains.
6	1167	Calcareous conglomerate	Pteropoda.
42	1415	Limestone ; green mud	Very few Foraminifera *Rhizammina algæformis*; Poriferan spicules.
45	38	Calcareous conglomerate	*Lithothamnion*, Polyzoa, Polychæta, *Pavona*, etc.
67	274	Limestone ; serpentinized enstatite peridotite; green mud	Pelagic and benthic Foraminifera, Pteropoda; fragments of benthic organisms.
72	73	Shelly conglomerate	Shells, especially *Turritella* sp.
111	73–165	Calcareous rubble	Encrusting shallow-water organisms.
209	366	Limestone ; green mud	Pteropoda; few solitary corals ; *Rhabdammina* sp.

(c. ii) *Sands.*—Nine samples of sands were obtained from shallow water ranging from $13\frac{1}{2}$ m. down to 220 m. They all contain some siliceous material though the percentage varies considerably, as the following table (Table VIII) shows :

TABLE VIII.

Station.	Depth (m.)	% insoluble residue (mainly siliceous).
24	73–200	13·6
27	37	6·2
53	13·5	32·4
80	16–22	..
89	193	..
103	101	11·4
112	113	..
113	220	38·0
178	91	..
Average	110 m.	20·3%

The type of sandy deposit is influenced considerably by the relative amount of siliceous

material present. Three representative samples are shown on Pl. II, figs. 2–4. The first (fig. 2), from Sta. 178, contains practically no siliceous material, and is a typical calcareous sand composed largely of rounded Molluscan shell fragments together with lesser amounts of other organisms, of which an Echinoid spine, *Balanus* scutum and fragments of Polychæt tubes, are identifiable in the figure.

Fig. 3 shows another terrigenous sand with a considerable amount of quartz grains, from Sta. 163 off Zanzibar. The darker particles in the figure are the quartz grains, many of which are coloured brown ; calcareous remains appear white or pale grey. The shell content of this sand is low and the chief sources of calcium carbonate are fragments of solitary corals, Polyzoa and occasional Foraminifera. This deposit is intermediate between the calcareous sand of fig. 2, and the very siliceous sand from Sta. 113, off Zanzibar, shown in fig 4. At this latter station calcareous remains are varied but none are very abundant. Pteropod shells are an interesting source of calcareous material in this deposit, which contains 38·0% of siliceous material, chiefly quartz grains.

As is to be expected, the animal remains present are mainly those of shallow-water organisms, especially of attached forms, that require a hard bottom. A few remains of animals from muddy sand, *e. g. Uvigerina pygmæa*, occur, and also some remains of pelagic organisms, though these are rare. The following composite list illustrates the kinds of animals met with in these shallow-water deposits :

Pelagic :—

Foraminifera.

Globigerina bulloides.
Globigerinoides rubra.
Orbulina universa.
Globorotalia menardii.

Pteropoda.

Limacina inflata.
Creseis acicula.
Cr. virgula.
Hyalocylis striata.
Clio pyramidata.
Diacria quadridentata.
Diacria trispinosa.
Cavolinia globulosa.
C. longirostris.
C. uncinata.
Atlanta sp.

Fish otoliths.

Benthic :—

Foraminifera.

Rhabdammina abyssorum.
Rhizammina algæformis.
**Reophax* sp.
**Haplophragmoides canariense.*
**H. grandiformis.*
Textularia agglutinans.
**T. carinata.*
**T. corrugata.*
T. gramen.
**T. porrecta.*
T. sagittula var. *atrata.*
**T. tuberosa.*
**T. trochus.*
Gaudryina rugulosa.
**Quinqueloculina agglutinans.*
**Q. intricata.*
**Q. rupertiana.*
Spiroloculina depressa.
Sp. grateloupi.
Sp. grateloupi var. *acescata.*
Sigmoilina schlumbergeri.
Triloculina tricarinata.
Tr. trigonula.
Pyrgo anomala.
P. murrhina.
P. sarsi,

P. vespertilio.
**Spirophthalmidium acutimargo.*
**Nubecularia tuberosa.*
**Carterina spiculotesta.*
Placopsilina cenomana.
Robulus convergens.
R. costatus var. *multicostatus.*
R. orbicularis.
Lenticulina rotulata.
Nodosaria flinti.
N. scalaris.
N. subscalaris.
Vaginulina legumen.
V. linearis.
**V. tricarinella.*
**Guttulina yabei.*
Sigmoidella elegantissima.
**Polymorphina ovata.*
**Nonion asterizans.*
**N. grateloupi.*
N. scaphum.
N. umbilicatulum.
**Nonionella ? auris.*
**Elphidium articulatum.*
El. craticulatum.
El. crispum.
**El. macellum.*
**Ozawaia tongaensis.*
Operculina gaimardi.
O. granulosa.
Heterostegina depressa.
Heterostegina operculinoides.
Sorites marginalis.
Marginopora vertebralis.
Alveolinella boscii.
Bolivina simpsoni.
**Chrysalidinella dimorpha.*
Uvigerina aculeata.
U. pygmæa.
U. tenuistriata.
**Discorbis globularis* var. *bradyi*
Gyroidina soldani.
Eponides præcinctus.
**Planopulvinulina dispansa.*
Rotalia calcar.
R. margaritifera.
R. papillosa.
Epistomina elegans.
**Sphæridia papillata.*
Amphistegina radiata.
**Planulina* sp.
Cibicides lobatulus.
C. refulgens.
Planorbulinella larvata.
Gyspina globulus.
G. vesicularis.
Carpenteria monticularis.
C. proteiformis.
C. utricularis.
Sporadotrema cylindricum.
Sp. mesentericum.
Miniacina miniacea.

Mollusca.

Conus sp.
Terebra sp.
Cadulus sp.
Dentalium sp.

Polyzoa.

Cellaria sp.
Haswellia sp.

Cirripedia.

Balanus sp.
Lepas sp.
Verruca sp.

* These species were found in the sands only.

Lithothamnioneæ, Hydrocorallinæ and *Hyalonema* spicules also occur in small quantities.

(d) *Globigerina Ooze.*

Globigerina ooze was obtained at sixteen stations ranging in depth from 353 to 3676 m.,

with one exceptionally deep sample from 4499 m. The average depth of the deposit below sea-level, computed from the station depths, is 2481 m. This depth compares favourably with the average depth of the " Valdivia " samples (Murray and Philippi, 1908, p. 140), some of which were obtained in the Indian Ocean, namely 2890 m. It is very near the average for the samples obtained by the same expedition in the north-west region of the Indian Ocean only, namely 2330 m. Taking these records into account an average depth for Globigerina ooze in the Arabian Sea of 2405 m. is obtained. This depth is slightly less than two-thirds the average depth for the deposit from the seas of the world given by Murray and Renard (1891, p. 214), namely 2002 fathoms (3696 m.). This average includes those deposits that could be called transitional ooze. If these were omitted, Murray's average depth for Globigerina ooze would be considerably lowered. The samples from below 4000 m. are mainly brown transitional oozes, but that from Sta. 173 at 4499 m. (the deepest at which Globigerina ooze was obtained) is exceptional in being a finely divided white Globigerina ooze with no appreciable amount of red clay.

The percentage of calcium carbonate has not been determined, but estimations were made of the weight of the recognizable Foraminiferal fragments, and these ranged from 9·7% to 48·9%; the average amount was 26·2%. The very high percentage of Foraminifera (48·9%) at Sta. 127 (at 4091 m.) is remarkable in that it is double that found at stations in similar depths. At this depth one would have expected the amount of calcium carbonate, and therefore of Foraminiferal tests, to have fallen off.

(e) *Transitional Ooze.*

Ooze transitional from Globigerina ooze to red clay was obtained at six stations ranging in depth from 3722 m. to 4234 m. The average depth of the samples obtained was 4038 m. These deposits all leave a considerable insoluble residue resembling red clay.

The biological composition of this deposit is very similar to that of pure Globigerina ooze. The main differences are that transitional ooze usually contains fewer Foramiferal tests and other calcareous remains, and that rather fewer benthic species of Foraminifera are present.

The biological composition of the two deposits is discussed below.

Biological Composition of Globigerina Ooze and Transitional Ooze.

The composition of these deposits from the biological standpoint is limited to a comparatively small number of pelagic forms but includes many benthic species. Only sixteen of the twenty-five truly pelagic species of Foraminifera listed by Cushman (1933, p. 44) were obtained in these oozes. The following is a list of all the species identified :

Pelagic :—

Globigerina bulloides.
Gl. dubia.
Gl. inflata.
Globigerinoides conglobata.
Gl. rubra.
Gl. sacculifera.
Globigerinella æquilateralis.
Gl. digitata.
Orbulina universa.
Pulleniatina obliquiloculata.
Sphæroidinella dehiscens.
Globorotalia canariensis.
Gl. crassa.
Gl. menardii.
Gl. truncatulinoides.
Gl. tumida.

Pteropoda.

Limacina inflata.
Creseis sp.
Cuvierina columnella.
Cavolinia sp.
Diacria quadridentata.
Atlanta sp.

Benthic :—

Foraminifera.

Rhabdammina abyssorum.
Rh. abyssorum var. *radiata.*
Rh. discreta.
Rh. linearis.
**Marsipella elongata.*
**Psammosphæra fusca.*
Saccammina sphærica.
**Tholosina bulla.*
**Hyperammina friabilis.*
**Dendrophrya ramosa.*
**Reophax nodulosus.*
**Ammodiscus incertus.*
**Ammodiscoides turbinatus.*
**Ammolagena clavata.*
**Cyclammina compressa.*
Spiroplectammina milletti.
**Textularia flinti.*
T. gramen.
T. sagittula.
Verneulina propinqua.
Gaudryina baccata.
Clavulina communis.
**Spiroloculina ? tenuis.*
Sigmoilina schlumbergeri.
**Triloculina* sp.
Pyrgo anomala.
P. denticulata.
P. depressa.
P. lucernula.
P. murrhina.
P. serrata.
Cornuspira carinata.
Planispirina sphæra.
Robulus convergens.
**R. subaculeatus.*
**Lenticulina subalata.*
Marginulina glabra.
Dentalina filiformis.
**Nodosaria hirsuta.*
**N. pauperata.*
Vaginulina legumen.
**Lagena distoma.*
Nonion umbilicatulum.
**Bolivinita quadrilatera.*
Bulimina aculeata.
B. ovata.
B. pyrula.
Virgulina subsquamosa.
Bolivina dilatata.
Uvigerina aculeata.
U. tenuistriata.
Siphogenerina striata var. *curta.*
**Rotalia broekhiana.*
Epistomina elegans.
Cancris auriculus.
Cymbaloporetta squamosa.
Ehrenbergina pacifica.
Chilostomella ovoidea.
Planulina ariminensis.
Pl. wuellerstorfi.
Cibicides lobatulus.

* These species occurred only in Globigerina ooze.

Lamellibranchiata, larval Gasteropoda, Echinoderm fragments, Ostracod valves and a few Coccoliths complete the list of calcareous remains present.

Siliceous remains include a few Diatoms, Radiolaria and Poriferan spicule-fragments.

As is to be expected, Foraminifera form the bulk of the animal remains. The pelagic forms, though smaller in the number of species, are by far the commonest. Except in occasional samples the bottom-living forms are scarce, and occur for the most part in those

samples of Globigerina ooze bordering on terrigenous muds. The above list of Foraminifera is in fair agreement with that given by Murray and Renard (1891, p. 214) for Globigerina ooze, and also with that of Hanzawa (1928, p. 68) for material from the south-west part of the North Pacific. The latter author, however, lists many more bottom-living species, the majority of which were very rare. Other organisms are usually conspicuous by their absence and again tend to occur more frequently in the deposits from lesser depths. Coccoliths are exceedingly rare, and were identified in a few samples only after a careful search of the finest material. Evidently they are not typical of the Arabian Sea, though, according to Murray and Renard (1891, p. 258), they are said to " play a most important part in all deep-sea deposits, with the exception of those laid down in polar and sub-polar regions".

As the above list shows, few siliceous remains occur. Radiolarian skeletons and Poriferan spicules could probably be demonstrated in most, if not all, of the samples of Globigerina ooze by dissolving out the calcium carbonate from a sufficient quantity; but such remains are exceedingly rare, and of no importance as ooze-forming organisms in this type of deposit. Diatom remains are even less common and are usually fragmentary.

Typical samples of the deposit are shown on Pl. II, figs. 5, 6. That shown on fig. 6, from Sta. 167, is of interest because of the great abundance of fragments of *Globorotalia menardii*, which is by far the commonest species in the deposit at this station.

(f) *Pteropod Ooze.*

Under the category of Pteropod ooze I have included all deposits in which the Pteropod and Heteropod shells total more than 5·0% by weight of the deposit. These deposits are all from the borders of the terrigenous mud areas, and might equally well be classed with these deposits except for the numerous remains of Pteropoda. Eight such deposits were found along the African coast, in the Gulf of Aden, at the southern end of the Red Sea, and in the Gulf of Oman, containing from 5·1% to 14·2% of Pteropod shells, with an average of 8·9% (average of six samples). A further ten samples, in which the shells amounted to less than 5·0% (averaging 1·6%) have been classed with the green, brown or grey muds, to which they more properly belong.

The depth of this deposit below the surface averages 255 m., with extremes of 155 m. and 411 m. This is far less than the average obtained by the " Valdivia " of 788 m. for twelve samples, and for those samples from the north-west area of the Indian Ocean alone the average obtained was 830 m. An average depth of 543 m. for the deposit in the North-west Indian Ocean is thus obtained. Both the present records and those of the " Valdivia " are from much shallower water than those obtained by the "Challenger". Murray and Renard give an average depth of 1044 fms. (1927 m.) for Pteropod ooze.

Pteropod ooze may exhibit marked differences in appearance in different areas. Thus the deposit from Zanzibar and that from the Gulf of Oman are formed of the elongated conical shells of *Creseis acicula* and *C. virgula* with some of the striated *Hyalocylis striata* (see Pl. III, fig. 2); other species of Pteropoda are rare or absent. Other deposits, as for instance those from the south end of the Red Sea, are composed largely of the shells of *Cavolinia* spp., all nine species of which are frequently present, as well as species of *Clio* and *Creseis* (see Pl. III, fig. 1).

The biological composition of a Pteropod ooze is shown by the following lists of species;

Pelagic :—

Pteropoda.

Peraclis reticulata.
Limacina inflata.
L. bulimoides.
L. helicina.
L. trochiformis.
Creseis acicula.
Cr. virgula.
Hyalocylis striata.
Styliola subula.
Clio pyramidata.
Cuvierina columnella.
Diacria quadridentata.
Cavolinia globulosa.
C. longirostris.
C. uncinata.
Atlanta sp.

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides conglobata.
Gl. rubra.
Gl. sacculifera.
Globigerinella æquilateralis.
Globigerinella digitata.
Orbulina universa.
Pulleniatina obliquiloculata.
Candeina nitida.
Globorotalia canariensis.
Gl. menardii.

Benthic :—

Foraminifera.

Rhizammina algæformis.
Reophax sp.
Trochamminoides proteus.
Cribrostomoides bradyi.
Textularia agglutinans.
T. conica.
T. pseudocarinata.
T. rhomboidalis.
T. sagittula var. *fistulosa.*
Clavulina angularis.
Cl. communis.
Cl. pacifica.
Cl. tricarinata.
**Quinqueloculina* sp.
Spiroloculina depressa.
Sp. grateloupi.
Sigmoilina schlumbergeri.
Triloculina tricarinata.
Pyrgo depressa.
P. sarsi.
P. vespertilio.
Robulus acutauricularis.
R. calcar.
R. denticuliferus.
R. gibbus.
**R. papillosus.*
Nodosaria paucilocularis.
**N. raphanus.*
Nodosaria scalaris.
N. vertebralis.
Saracenaria italica.
Nonion boueanum.
Operculina granulosa.
Sorites marginalis.
Bulimina ovata.
B. pagoda.
B. pyrula.
**Virgulina* sp.
Bolivina amygdalæformis.
B. beyrichi.
B. beyrichi var. *alata.*
**B. compacta.*
B. robusta.
Uvigerina brunnensis.
U. pygmæa.
**Discorbis vilardeboana.*
**Eponides haidingeri.*
Ep. præcinctus.
Rotalia margaritifera.
R. papillosa.
Ehrenbergina pacifica.
Chilostomella ovoidea.
Cibicides lobatulus.
C. refulgens.
Miniacina miniacea.

* These species were found in Pteropod ooze only.

Pteropod ooze is thus characterized by the large number of shells, and shell-fragments, of Pteropoda, the small number of *Globigerinæ*, though all the species found in Globigerina ooze may be present, and the large number of benthic Foraminifera, the number of species of these last (60) being practically the same as that found in Globigerina ooze (61). The species, however, are mainly those found in green mud. Forty-one species are common to the green mud and Pteropod ooze and only eight to Pteropod ooze and Globigerina ooze. This is, of course, to be expected, as the Pteropod oozes occur on the edge of the green muds, whereas Globigerina ooze extends into much deeper water. Most of the species occur in small numbers only.

Other remains of organisms, such as shell and Echinoderm fragments, are present, as in green mud. The average composition of four Pteropod oozes is given in Table IX, but owing to the extreme variability in the percentages the average values have little significance.

Table IX.

Group.	Average % deposit.	Variation.
All remains	58·0	74·7–39·0
Echinodermata	5·7	16·9–0·9
Lamellibranchiata	10·5	22·9–0·4
Gasteropoda	9·3	17·5–0·9
Pteropoda	9·7	14·2–5·1
Pisces	0·8	1·7–0
Other remains	22·0	..
Total	58·0	

The 22% "Other remains" is composed of various other macrofauna and Foraminifera.

The number of species of Pteropoda actually found in the deposits is low. The species of *Cavolinia* especially are often lacking, though all the known species occur in the plankton of the north-west region of the Indian Ocean. Murray and Renard (1891, p. 224) list thirty-five species of Pteropoda and thirty-two of Heteropoda that may occur in Pteropod ooze. Only fifteen species were actually present in the samples examined, though six more were found in other types of deposit. Hanzawa (1928, p. 73) only found nine species of Pteropoda in oozes from the north Pacific. The Heteropoda have not been identified, but *Atlanta* spp. were of frequent occurrence both in Pteropod ooze and in other deposits. The distribution of Pteropod shells in the deposits is discussed elsewhere (p. 145).

The following six species of Pteropoda were found occasionally in various deposits though not in Pteropod ooze :

Peraclis bispinosa.
Clio cuspidata.
Diacria trispinosa.
Cavolinia gibbosa.
C. inflexa.
C. tridentata.

A comparison of the species identified from the plankton and the deposits shows the following differences :

Species apparently present only in—

Plankton.	Deposits.
Clio chaptali.	*Peraclis bispinosa.*
	P. reticulata.
	Limacina bulimoides.
	L. helicina.
	Cuvierina columnella.
	Cavolinia gibbosa.

Clio chaptali would appear to be a rare Arabian Sea species. It occurred only twice in the plankton hauls made by the expedition, each time a single specimen being obtained. The species found in the deposits only were likewise infrequent except for *Cuvierina columnella* and *Cavolinia gibbosa*. This is probably due to the small size and delicate nature of the shells of *Peraclis* and *Limacina*, which tend to break up readily. The same reason probably accounts for their absence from the plankton hauls. It is highly probable that the shells were damaged by shaking or by the preservative and so were lost or rendered unrecognizable. *Cuvierina columnella* and *Cavolinia gibbosa* have a much more resistant shell, and would be expected to withstand contact with the particles of the deposit. These two species, however, were obtained only in the Zanzibar area, where they were quite frequent. It is remarkable that they did not occur in the plankton. At present these species have not been found alive, or as deposit-shells north of the equator in the Arabian Sea, though there are several records of both species from south of the line.

(g) *Red Clay.*

Only three samples of a deposit were obtained that could be assigned to this formation. They ranged in depth from 4285 m. to 5082 m., averaging 4720 m. This depth is 500 m. less than the average obtained by the " Valdivia " for red clay, 5288 m., and 300 m. less than the average given by Murray and Renard (1891, p. 190), 2730 fms. (5040 m.), for red clay in general.

The three samples of red clay are very pure. Calcareous remains were found in one sample only (Sta. 100), in very small quantities. Siliceous remains occurred in the samples from Stas. 100 and 101, a few sponge spicules and *Coscinodiscus* sp. being present but no Radiolaria. The third sample from Sta. 166 contained no calcareous or siliceous remains.

Two other samples from Stas. 134 and 167 contained a large amount of red clay but, as they also contained large numbers of the species typical of Globigerina ooze, they have been included under the heading of " Transitional Ooze ".

The deposit from Sta. 166 was associated with large numbers of manganese nodules, about 125 kg. of which were obtained in one haul of the trawl.

The red clay, like the grey clay already described, supports a very poor fauna and contains very few remains of pelagic organisms. This absence of remains in red clay has always been ascribed, among other factors, to the immense pressure in the depths raising the solubility of calcium carbonate and silica so that all the *Globigerinæ* and other remains are dissolved, with the exception of some of the siliceous structures. In grey clay there is a very poor fauna, but owing to the lesser depth this cannot be ascribed to the high pressure. It is thus probable that the cause of the paucity of the fauna is different in the two instances. In the grey clay area of the northern Arabian Sea the bottom-water is poor in oxygen, and in parts the deposit, and perhaps also the overlying water, is charged with

hydrogen sulphide. Conditions are thus unfavourable for animal life. Farther south, in the red clay area, the oxygen content of the water is slightly higher. The amount of organic matter is about the same as in the grey clay. These then cannot be the factors limiting life. It is possible that the depth is the limiting factor here, very few animals having become adapted to life in the greatest depths.

The increased oxygen-content of the water appears to have a considerable effect on the deposit. At the northern end of the Arabian Sea, where the oxygen deficiency is greatest, grey clays are deposited. Further south, under conditions of better oxygenation, red clays are laid down.

(h) *Deposits from the Maldive Archipelago.*

These deposits consist of sands and muds from the lagoons and the outer slopes of the atolls. Nine samples were obtained from the lagoons and eleven from the outer slopes of the atolls.

(h. i) *The Lagoon muds.*—Five samples of mud and four of sand were obtained in the lagoons. The composition of the two deposits is very different and there appears to be little overlap of the two deposits. The depth and percentage of large material of animal origin in the muds is given below :

Station.	Depth (m.).	% large animal remains.
137	46	8·5
142a	31	(24·9)
142b	37	6·4
147	27	6·7
160	37	5·4
Average	36 metres	6·75% (of 4 only)

The percentage of larger animal fragments is thus fairly constant about 7·0%, except for Sta. 142a from Fadiffolu Atoll. These deposits contain remains of most shallow-water bottom-living organisms, but never in any quantity. Pelagic animals are represented by :

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides conglobata
Gl. rubra.
Gl. sacculifera.
Globigerinella æquilateralis.
Globigerinella digitata.
Orbulina universa.
Globorotalia canariensis.
Gl. crassa.
Gl. menardii.

Pteropoda.

Creseis acicula.
Cr. virgula.
Diacria quadridentata.
Cavolinia longirostris.

Bottom-living Foraminifera are few in species and rare in comparison with other deposits. The following species occur :

**Bathysiphon filiformis.*
Aschemonella ramuliformis.
Trochamminoides proteus.
Textularia conica.
T. foliacea.
**T. haueri.*
Clavulina communis.
**Quinqueloculina ferussacii.*
**Q. reticulata.*
**Massilina inœqualis.*
Spiroloculina canaliculata.
Sp. grateloupi.
Pyrgo vespertilio.
Laticarinina pauperata.
Dentalina consobrina var. *emaciata.*
Nodosaria pyrula.
Nodosaria sp.
Nonion boueanum.
Elphidium craticulatum.
Operculina gaimardi.
O. granulosa.
Heterostegina depressa.
H. suborbicularis.
Amphisorus hemprichi.
Borelis melo.
Alveolinella boscii.
Epistomina elegans.
Amphistegina radiata.
Gypsina globulus.

* These five species were found in the Lagoon muds only.

Crustacean material is quite common in most of these muds. Segments of the limb skeleton and large fragments of the carapace are of frequent occurrence. Other remains are very variable. Gasteropoda were abundant at Sta. 137, but were rare at Sta. 160, where small Lamellibranch valves were very common. *Creseis* spp. were present in four of these muds and were abundant at Sta. 160, but were absent from Sta. 142a. The type of material left on sieving coral mud is shown on Pl. III, fig. 6, which is from material obtained at Sta. 142b.

(h. ii) *The Lagoon sands.*—In the lagoon sands fragments of animal origin are very plentiful. Few pelagic organisms, but many bottom-living forms, are present among the remains. These sands and gravels are almost entirely of calcareous origin, and consist mainly of the remains of bottom-living species, especially corals and shells and sometimes also Foraminifera, as at Sta. 139, where they form over 50% by weight of the deposit (see Pl. III, fig. 3). Coralline algæ frequently form a large part of the deposit, as at Sta. 144, where fragments of *Halimeda* sp. are common (see Pl. III, fig. 4). Table X below gives the amount of animal fragments in these sands :

Table X.

Station.	Depth (m.).	% large animal remains in deposit.
139	57	87·2
141	44	50·6
144	31	42·7
161	46	31·5
Average	45 metres	53·0%

The percentage of larger animal material thus varies very considerably in the sands, but is always of a high order. The actual percentage probably depends upon the amount of tidal scour to which the deposit is exposed.

The lagoon sands are characterized by the absence of pelagic organisms. The only true pelagic organism found was a shell of *Atlanta* sp. *Tretomphalus bulloides* occurred in small numbers, but this species is not a true pelagic Foraminiferan, as it is attached in the young stages and only becomes pelagic as a fully grown organism. It is a shallow-water species. The following is a list of the Foraminifera present :

Textularia agglutinans.
**T. candeina.*
T. conica.
T. foliacea.
T. gramen.
**T. pseudotrochus.*
Quinqueloculina kerimbatica.
**Q. parkeri.*
**Massilina australis.*
Spiroloculina grateloupi.
**Sp. tenuissima.*
**Schlumbergerina alveoliniformis.*
Triloculina oblonga.
Tr. tricarinata.
Placopsilina cenomana.
**Robulus* sp.
Elphidium craticulatum.
El. crispum.
Operculinella cumingi.
Operculina gaimardi.
O. granulosa.
Heterostegina depressa.
H. suborbicularis.
Marginopora vertebralis.
Borelis melo.
Alveolinella boscii.
Amphistegina radiata.
Calcarina defranci.
Cymbaloporetta bradyi.
C. squamosa.
**Acervulina inhærens.*
Gypsina vesicularis.
Carpenteria proteiformis.
C. utricularis.
Homotrema rubrum.
Sporadotrema cylindricum.
Miniacina miniacea.

* These species were identified from lagoon sands only.

In addition to the above, remains of Alcyonaria, Polychæta, Lamellibranchiata, Gasteropoda, Scaphopoda and Echinodermata occur.

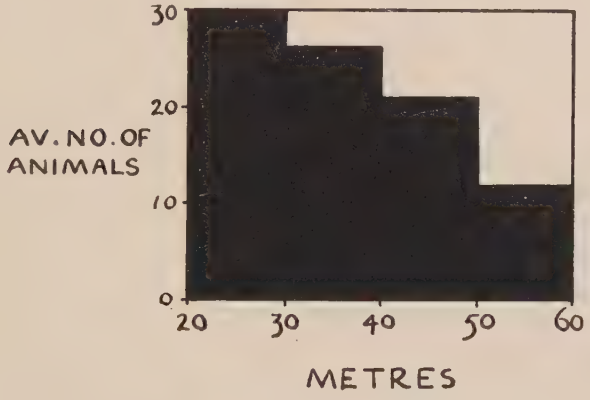
The muds and sands of the lagoons thus differ considerably *inter se* in their contained organic materials. The muds tend to contain a representative selection of pelagic species which are almost entirely absent from the sands. The sands, on the other hand, are composed of remains of benthic organisms, especially Foraminifera, which may be present in considerable numbers. The bottom-living Foraminifera in the two deposits belong mainly to different species. Twenty-eight species were identified from the muds and thirty-six from the sands, but only ten species are common to both deposits. Most of these latter are common, widely-distributed forms, such as *Alveolinella boscii* and *Amphistegina radiata*, that occur over a wide depth range, and in deposits varying from coarse littoral sands and gravels to fine muds from several hundred metres' depth.

It follows, then, that the lagoon bottom must present two very different types of habitat. There is the fine calcareous mud or ooze, apparently accumulating in calm water and in some cases containing sulphuretted hydrogen. Alternatively there are hard sandy or even gravel bottoms, exposed to current action, which keeps the mud from accumulating, and which are suitable for an entirely different set of animals.

The numbers of living animals obtained in hauls with the Priestman grab are shown in Table XI.

TABLE XI.

Depth (m.).	Station.	Number of successful hauls.	Animals. Total.	Animals. Average haul.	Animals. Average 10 m. interval.	Remarks.
27	147	1	30	..	30	..
31	142a 144	1	0 22	22	26	H_2S ..
37	142b 160	2	15 42	29		H_2S H_2S
44	141	1	31	..	21	..
46	137 161	2	27 6	17		H_2S ..
57	139	1	12	..	12	..



TEXT-FIG. 4.—Number of animals caught by grab in the lagoons of the Maldives.

At Sta. 142a no animals were caught and H_2S was present in the mud. This station was therefore neglected in obtaining the average number of animals per haul, as elsewhere the presence of this gas did not exclude the fauna. The gas was present at Stas. 137, 142b and 160, but animals were caught at all of these.

The above figures are reproduced in Text-fig 4. They indicate that there is a high population in the lagoons in about 20–30 m., which falls off steadily as the depth increases. There are no records from below 57 m., but as this is near the maximum depth for most lagoons we may expect the deeper waters to support about this number of animals per 0·5 sq. m.

There was no H_2S at Sta. 161 to account for the very low figure of only six animals in the haul from 46 m., and Sta. 137 at the same depth gave the second best haul in the lagoons, 27 animals being caught, despite the presence of hydrogen sulphide in a concentration estimated at 4·9 mgrm. per litre of water aspirated off the mud.

(h. iii) *Deposits from the Outer Reef-slopes.*—Eleven samples were collected from the outer slopes of the reefs in depths from 101 to 1280 metres. The majority are clean or muddy sands, with varying amounts of animal remains as Table XII indicates.

TABLE XII.

Station.	Depth (m.).	% animal remains.
143	797	78·0
145	494	48·3
149	238	..
151	101	..
152	878	65·6
157	229	..
158	914	..
159	1280	(5·5)
163	274	35·9
164	183	30·5
165	366	86·3
Average	523 metres	57·4% (of 6 only).

The percentage of animal remains in these deposits is again high—higher even than in the shallower lagoon sands. The deposit is, however, of a finer nature, as much of this percentage is made up of the tests and fragments of *Globigerinæ* and other pelagic organisms. Apparently much of the finest material is removed from this region by current action so that a fine sand is deposited instead of a mud, as in parts of the lagoons. The removal of fine mud only seems to occur down to about 1000 metres, as below this (*e. g.* at Sta. 159) mud is found with only a low percentage of animal fragments, and which approaches a Globigerina ooze in its composition. Coral muds thus appear to grade into Globigerina ooze at about 1000 metres. A sample of the animal remains occurring in these "slope" deposits, from Sta. 163, is shown on Pl. III, fig. 5.

The Foraminifera represent a very mixed fauna, as the deposit has characteristics of several of the more distinct deposit-types. Thus in shallow-water samples species from the sands and muds of the lagoons occur. In deeper water the deposit occupies the place of the terrigenous muds on the Continental slope, and many of the species occurring in the green and brown muds occur here also. Throughout its range the deposit contains considerable numbers of pelagic species, especially in the lower depths, where it grades into Globigerina ooze. Some of the bottom-living species of the Globigerina ooze are also present. Finally there are a number of Pteropoda present, as the deposit occupies the depths in which Pteropod ooze might be expected to occur. In this the deposit again parallels the green muds on the edge of the Globigerina ooze, which contain many Pteropoda and sometimes pass into Pteropod ooze.

The following is a list of the Foraminifera and Pteropoda found in this deposit:

Foraminifera.

Globigerina bulloides.
Gl. dubia.
Globigerinoides conglobata.
Gl. rubra.
Gl. sacculifera.
Globigerinella æquilateralis.
Gl. digitata.
Orbulina universa.
Pulleniatina obliquiloculata.
Sphæroidinella dehiscens.
Globorotalia canariensis.
Gl. crassa.
Gl. menardii.
Gl. truncatulinoides.
Gl. tumida.

**Reophax scorpiurus.*
Haplostiche dubia.
Aschemonella ramuliformis.
**Haplophragmoides scitulum.*
Ammobaculites calcareum.
Spiroplectammina milletti.
Textularia agglutinans.
T. conica.
T. foliacea.
T. gramen.
T. sagittula.
**Verneulina bradyi.*
**V. triquetra.*
Gaudryina baccata.
G. rugulosa.
Clavulina communis.
**Cl. parisiensis.*
Quinqueloculina kerimbatica.
Spiroloculina depressa.
Sp. grateloupi var. *acescata.*
Sigmoilina schlumbergeri.
Triloculina oblonga.
Tr. tricarinata.
Pyrgo anomala.
P. denticulata.
**P. milletti.*
P. murrhina.
P. vespertilio.
Biloculinella globula.
**Cornuspira involvens.*
**Robulus lucidus.*
R. orbicularis.
**Lenticulina d'orbignyi.*
L. rotulata.
**Dentalina elegans.*
Nodosaria subscalaris var. *pauci-costata.*
Saracenaria italica.
**Lingulina grandis.*
**Polymorphina lanceolata.*
Elphidium craticulatum.
El. crispum.
Operculinella cumingi.
Operculina gaimardi.
O. granulosa.
Heterostegina depressa.
H. operculinoides.
H. suborbicularis.
Sorites marginalis.
Amphisorus hemprichi.
Marginopora vertebralis.
Borelis melo.
Alveolinella boscii.
Bulimina aculeata.
B. elongata.
B. ovata.
Uvigerina pygmæa.
U. schwageri.
**Siphogenerina columellaris.*
**S. raphanus.*
Angulogerina carinata.
Gyroidina soldani.
Rotalia calcar.
Epistomina elegans.
Cancris auriculus.
Amphistegina radiata.
Calcarina defranci.
Cymbaloporetta bradyi.
C. squamosa.
Cymbaloporella tabellæformis.
Chilostomella ovoidea.
Planulina wuellerstorfi.
Laticarinina pauperata.
Cibicides lobatulus.
Planorbulinella larvata.
Gypsina globulus.
Carpenteria monticularis.
C. proteiformis.
C. utricularis.
Homotrema rubrum.
Sporadotrema cylindricum.
Sp. mesentericum.
Miniacina miniacea.

Pteropoda.

Limacina bulinoides.
L. inflata.
L. trochiformis.
Creseis acicula.

* These species were found only in the deposits from the outer slopes of the Atolls.

Table XIII.

Deposit.	Depth range (m.).	Average % animal remains.	Foraminifera.		Pteropoda.	Diatoms.	Radiolaria.	Mollusca. L. = Lamell. G. = Gasterop.	Echinodermata.	Polychæta.	Pisces.
			Pelagic.	Benthic.							
Grey clay	274–1703 (av. 867)	7·7%	6 spp.	8 spp.	7 spp.	..	..	L.+ G.+	..	..	+
Grey mud	1687–3556 (av. 3135)	4·8%	9 spp.	28 spp.	7 spp.	+	+	L.+ G.+	+	+	+
Terrigenous muds (gn. and br.)	91–2072 (av. 793)	9·3%	15 spp.	192 spp. Usually rare; some species locally abundant, e.g. Stas. 105, 185	17 spp.	*Coscinodiscus* locally abundant, e.g. Stas. 55, 56	..	Common, locally abundant	Usually present, often abundant	Common	Frequent
Terrigenous sand	13·5–220	..	4 spp.	86 spp.	11 spp.	..	..	Very variable			Few otoliths
Conglomerate	38–1415	..	Few	Very few	7 spp.	..	..	Few	Few	Few attached tubes	..
Globigerina ooze	353–4499 (av. 2779)	27·3%	Av. 26·2%		7 spp.	+	+	Very few			Frequent
Pteropod ooze	155–411 (av. 255)	58·0%	16 spp. 12 spp.	61 spp. 44 as in gn.m. 60 spp., 8 as in gl. oz., 41 as in gn.m.	14·2–5·1%; 16 spp.	..	..	L. av. 10·5% G. av. 9·3%	Av. 5·7%	Frequent	Av. 0·8%, frequent
Red clay	4285–5082 (av. 4720)	Practically *nil*	..	..	..	Very few *Coscinodiscus*	..	..	..	..	..
Lagoon mud	27–46 (av. 36)	5·8%	11 spp.	28 spp.	4 spp.	..	..	Few only			
Lagoon sand	31–57 (av. 45)	53·0%	..	36 spp., 10 only as in lagoon mud	1 sp.	..	..	Very common			..
Outer reef slope deposits	101–1280 (av. 523)	57·4%	15 spp.	80 spp. lagoon, shallow water, and gl. ooze spp.	15 spp.	..	..	L. = <2% G. = c.7%	<1·0%	Few	Few otoliths

Cr. virgula.
Hyalocylis striata.
Clio cuspidata.
Cl. pyramidata.
Cuvierina columnella.
Diacria quadridentata.
Cavolinia gibbosa.
C. globulosa.
C. longirostris.
C. uncinata.
Atlanta sp.
Otoliths.

(j) *Summary of the Composition of the Deposit Types.*

Table XIII summarizes the depth distribution and composition of the various deposit types discussed in the foregoing pages.

(k) *The Effect of the Deposit Type on the Fauna.*

The type of deposit present appears to have a considerable effect upon the numbers of animals inhabiting an area, as it is hoped to show from the hauls taken with the grab on different types of sediment. The effect is probably due to the potential food value of the deposit as well as to its texture.

Most of the grab samples are green or brown muds and these will be considered first. Animals were obtained at sixteen different depths, representing twenty-two hauls, and varied in numbers from as many as fifty-one downwards. Eleven samples contained more than ten specimens, five less than ten and the remaining six none. If the unproductive hauls are omitted the remainder average about 20 animals per 0·5 sq. m., allowing for those recorded as " few " or " several." For all twenty-two hauls the average is about 14 per 0·5 sq. m. The number of phyla or lesser groups present is low in all hauls—usually between two and four ; even in the haul with fifty-one animals only four groups were represented. Four of the six samples containing no live animals are quite distinct from the others. The bulk of the deposits are green or greenish-brown muds. In two instances hydrogen sulphide was present. One of these samples, from Sta. 77, contained no life, and the other, from Sta. 189, only four organisms. The other five barren samples all came from the Zanzibar Area. One, from Sta. 103, is a sandy, noncoherent green mud, almost classifiable as a muddy sand ; another, from Sta. 113, is a muddy sand. There appears no reason why these deposits should contain no live animals, and the samples are probably not representative of the locality. At Sta. 105 the deposit is a very clayey mud, almost a grey clay, and as has been seen (p. 110), this latter type of deposit seems to support few or no animals. The remaining two barren samples are from Stas. 114 and 125. The deposit at both of these is recorded as a light brown or yellowish mud overlying grey-green mud and grey clay respectively. This light brown mud appears to be peculiarly unable to support animal life. It was found also at Sta. 5 in the Red Sea, and here, again, nothing was caught in the dredge.

The grey-white muds of the Maldive area are capable of supporting a considerable fauna. The number of animals present here is considerably higher than in the majority of examples of green or brown mud, as the following summary of hauls shows :

Station.	Number of animals.	Number of groups present.
137	28	6
142b	40	6
147	30	4
160	42	3
164	38	5
Average	36	5

The number of groups represented is likewise rather higher. This greater abundance of animals in the shallow water of the lagoons is perhaps due to the greater production of vegetable matter in the shallow illuminated waters. This vegetable matter and that derived from land vegetation forms a primary source of food for the plant- and detritus-feeders, and these in turn for the predatory species.

There remain to be considered the coarser deposits, which may for this survey be put into two groups—the sand and rubble deposits of the continental shelf, and the sands and gravels of the Maldives. The latter are separable into coarse lagoon deposits and coarse deposits from deep water on the outer slopes of the atolls.

On the continental shelf there appears to be much less life in these deposits than in the muds. Of five samples, two yielded no animals at all and the other three varied up to twenty. The number of groups represented is fairly high, four and five, but at the third station (Sta. 89) the twelve specimens obtained all belonged to one species of *Cardium*-like Lamellibranch. The records for these stations and the Maldives are tabulated below :

	Station.	No. of animals present.	No. of groups present.
Continental shelf	89	12	1
	90	..	..
	112	" Several "	4
	113	..	..
	178	20	5
Outer slopes of atolls	149	7	6
	150	..	..
	151	7	5
	163	11	3
	165	..	..
Lagoons	139	12	5
	141	31 + " several "	6
	144	22	8
	161	8	6

The fauna on coarse deposits on the slopes of the atolls thus appears to be rather similar in quantity to that from similar deposits on the continental shelf. The sands and gravels of the lagoons, however, obviously support a denser and more varied fauna. This fauna is very different from that of the lagoon muds. It consists chiefly of attached or sedentary animals or actively moving forms such as Crustacea. There are far fewer of the

burrowing and mud-feeding forms present. In other words here the " epifauna " is developed in place of the " in-fauna."

In the following table (Table XIV) the number of times each of the different groups was obtained in each of the four types of deposit is shown. The figures in black type indicate that the animals recorded belong to the epifauna. It is readily seen that the Cœlenterata, except for the Actinians and solitary corals, some of which live in the mud, belong to this attached fauna. They require a solid substratum, and do not occur on a muddy bottom whether this is of continental or coral origin. The solitary corals and perhaps the Actinians, on the other hand, may prefer a mud bottom. The single Actinian recorded, however, is probably an odd epizoic specimen dislodged from its support. Polyzoa were obtained only on the hard coral bottom. In contrast, the Polychæta were obtained no less than fourteen times (out of a possible twenty) in the green and brown muds and five times in the fine white coral muds, but not at all in the coarser sandy deposits.

TABLE XIV.—*Number of Times Different Animals were Obtained by Grab in the Deposits.*

Group.	Green and brown mud.	White mud.	Sandy bottom.	Coral bottom.
Porifera	..	..	**2**	**6**
Hydroids	..	..	..	**2**
Actinians	1	..	..	..
Alcyonacea	..	..	**1**	**1**
Gorgonacea	..	..	**1**	..
Madreporaria (colonial)	..	..	**1**	**1**
Madreporaria (solitary)	2	..	..	**2**
Polyzoa	..	..	..	**1**
Polychæta	14	5	..	..
Sipunculoidea	..	2	..	2
Crustacea (unspecified)	3	..	..	..
Amphipoda	..	1	..	..
Isopoda	1	1	..	..
Stomatopoda	2	3	..	1
Paguridea	..	1	..	1
Galatheidea	..	..	**1**	**1**
Prawns	..	..	**1**	**2**
Brachyura	5	4	**1**	**3**
Asteroidea	1	..	..	..
Ophiuroidea	3	2	..	3
Echinoidea	2	2	..	..
Holothuroidea	2	..	..	1
Mollusca (unspecified)	..	..	..	**1**
Lamellibranchiata	4	1	1	**3**
Gasteropoda	1	..	..	**2**
Scaphopoda	1	..	..	..
Pteropoda	..	..	1	..
Pisces	..	..	..	**1**
Algæ	..	..	**1**	..

The occurrence of the Sipunculoidea is interesting. These were obtained twice in coral mud and twice in the coarse coral deposits, but not in either of the deposits of the Continental Shelf. Apparently, therefore, it is not so much the fineness of the deposit which affects these animals as its chemical composition, a highly calcareous deposit being preferred to one with less calcium carbonate. It is not a question of these animals being limited to shallow lagoon water, as the above records range from 27 to 274 m., the latter depth being at a station well outside the atoll of Minikoi. It is probable that these animals subsist on coral and coralline algal detritus broken off from the reefs by the action of the surf and boring organisms.

The burrowing Stomatopoda prefer a muddy bottom to one composed of sand or gravel, though in one haul (Sta. 141) a single specimen was obtained from a depth of 44 m. on a gravel bottom. The Isopoda also apparently prefer a muddy bottom, not having been taken on the coarser substrata. On the other hand the Prawns and Galatheidea appear to prefer the coarser deposits, probably as these afford more protection under pebbles and shells and in the growth of attached forms. There is also less mud to clog the gills. Brachyura, on the other hand, were frequently obtained on muds even in the presence of sulphuretted hydrogen. Thus at Sta. 77 the mud smelled strongly of sulphuretted hydrogen and the grab obtained no animals, but the Salpa dredge procured a single specimen of the crab *Parilia alcocki* Wood-Mason. Crabs also occurred frequently on the coarse coral deposits, though only once were they obtained on a sandy terrigenous bottom. None of the crabs have been identified, but it is highly probable that those from the muds will prove to be of very different types to those from the coral bottom, each type preferring its own type of bottom and not encroaching on the domain of the other to any extent. The one set would be adapted for living on or in the mud, whereas the others, adapted for a life above the mud among the corals, hydroids, etc., would be smothered if transferred to a soft mud.

The Echinodermata prefer the mud bottoms to the coarser materials except for the Ophiuroidea which were common on the coarse coral deposits. Here again there are probably two sets of species, one being epizoic forms living on or in sponges, on Gorgonians, hydroids, etc., whereas the others are true bottom-living species dwelling on or in the mud.

With regard to the Mollusca it is not possible to make a definite statement. Both Lamellibranchiata and Gasteropoda were obtained several times on terrigenous mud and on coarse coral bottoms. These may be attached forms of the epifauna present on the hard bottom. On the other hand, the molluscs from the hard bottom may be part of the true mud fauna living in the finer parts of these coarse deposits. A similar condition has been shown by Petersen (1914, p. 16) for Danish waters, where the true in-fauna is present though obscured by a large development of an epifauna—in his instances a mussel-bed. Here the bivalves and Gasteropoda may form the in-fauna with a considerable epifauna of attached forms and commensals, greatly restricting the area available for the mud-dwellers.

V. THE DISTRIBUTION OF VARIOUS REMAINS IN THE DEPOSITS.

The amount of the remains of any of the more commonly occurring groups present in the deposits fluctuates violently over very small depth ranges in shallow waters, indicating that factors other than depth operate to determine the abundance of any group. This fluctuation is well seen in Table XV, showing the percentages of various groups from stations of equal depth.

TABLE XV.

Depth (m.)	46.		91.			274.				
Station	137.	161.	73.	178.	189.	67.	88.	163.	179b.	191.
Foraminifera	tr.	4·4	1·2	0·3	0·3	..	..	1·6	tr.	tr.
Echinodermata	0·3	0·1	1·4	0·3	0·1	..	..	0·8	1·9	0·1
Lamellibranchiata	0·5	3·8	30·0	1·9	6·3	..	0·5	2·1	1·5	1·4
Gasteropoda	7·1	6·3	7·8	5·0	15·3	..	0·2	6·8	2·1	0·2
Pteropoda	0·3	..	1·5	tr.	0·4	3·1	0·6	0·3	1·1	0·2
Scaphopoda	..	..	0·1	tr.	0·4	..	..	..	..	0·1
Total%	8·2	14·6	42·0	7·5	22·8	3·1	1·3	11·6	6·6	2·0

These fluctuations cease at about 400 m. and the individual percentages remain relatively constant at about 2·0% or less for the next 300 m. This low percentage over the range 400–700 m. corresponds to the minimum amount of total remains shown in Text-fig. 1 (p. 114), and shows that the minimum in this curve is due to a general reduction in the amount of all groups and not to the absence of one or two. This phenomenon, shown by the fauna, has been pointed out by Hesse (1924, pp. 20, 262), drawing examples from the total number of species collected by the "Challenger", from the species of Ascidians and Brachyura of that expedition and from the Foraminifera collected by the "Gazelle". This general decrease in the amount of animal remains, and therefore of animals, is due to the effect of the increased depth excluding much of the fauna, under uniform conditions of the bottom. In shallow water the effect of depth is largely masked by that of the less uniform nature of the bottom.

The distribution of various remains in the deposits is considered in the following pages.

(a) *Pteropoda.*

The shells of Pteropoda are among the most commonly occurring remains to be found in the sediments of the Arabian Sea. As the sample analyses (section II) show, the percentage weight of the sediments formed by these shells is seldom high. The highest amounts found were 14·2% and 11·2% (Stas. 28 and 75 respectively). Two other localities (Stas. 206, 207) gave 8·0% and 8·1% respectively. These values are all far higher than the normal for this group of remains. The average value is only about 1·0%. Naturally such a low percentage does not give the mud a characteristic appearance, and the shells are usually inconspicuous in intact samples. On sifting the mud, however, the shells are readily distinguishable and may form a considerable portion of the siftings, and in a few cases (Pteropod ooze) may far outnumber and outweigh other remains, which may be very scarce.

Table XVI shows all the species of Pteropoda identified from the sediments, the number of times each was obtained, and the localities where they occurred.

TABLE XVI.

Species.	Number of times obtained.	Red Sea.	Gulf of Aden.	Gulf of Oman.	South Arabian Coast.	Northern Arabian Sea.	Zanzibar area.	Maldive area.	Number of areas.
Peraclis depressa	2	..	2	..	..	..	..	..	1
P. reticulata	1	..	..	..	1	..	..	..	1
Limacina inflata	20	5	10	1	..	2	..	2	5
L. helicina	2	1	..	1	..	..	..	..	2
L. bulimoides	4	1	3	..	..	..	..	..	2
L. trochiformis	4	1	3	..	..	..	..	..	2
Creseis acicula	37	6	8	3	5	2	7	6	7
Cr. virgula	26	6	7	4	3	2	1	3	7
Hyalocylis striata	21	6	8	3	2	2	..	..	5
Styliola subula	1	..	1	..	..	..	..	..	1
Clio cuspidata	8	..	3	..	..	..	4	1	3
Cl. pyramidata	31	5	10	1	2	2	7	4	7
Cuvierina columnella	7	..	1	..	..	..	6	..	2
Diacria quadridentata	37	6	11	4	4	3	6	3	7
D. trispinosa	6	..	3	..	..	..	3	..	2
Cavolinia gibbosa	6	..	..	..	..	..	6	..	1
C. globulosa	10	3	1	..	..	..	5	1	4
C. inflexa	10	1	3	1	..	..	5	..	4
C. longirostris	47	6	14	5	5	4	7	6	7
C. tridentata	15	1	2	..	..	..	10	2	4
C. uncinata	32	5	9	..	..	3	10	5	5
Total number of species	21	14	18	9	7	8	13	10	..

The above table includes six species not obtained in the plankton hauls, namely:

Peraclis depressa. *Limacina helicina.*
P. reticulata. *Cuvierina columnella.*
Limacina bulimoides. *Cavolinia gibbosa.*

On the other hand one species, *Clio chaptali*, obtained in the plankton hauls, was not identified from the sediments.

Judging by the number of times each was taken, the commonest species appear to be *Cavolinia longirostris*, *Diacria quadridentata*, *Creseis acicula*, *Cavolinia uncinata*, *Clio pyramidata*, *Creseis virgula*, *Hyalocyclis striata* and *Limacina inflata*, in this order. Of these eight, the following occurred in all seven areas given in Table XVI :

Creseis acicula. *Diacria quadridentata.*
Cr. virgula. *Cavolinia longirostris.*
Clio pyramidata.

These are the most widely distributed species in the north-west area of the Indian Ocean. The other three species listed above, *Limacina inflata*, *Hyalocylis striata* and *Cavolinia uncinata*, occurring in five of the areas, are next in order of distribution. The distribution of the less common species is seen from the table, the last column giving the number of regions in which each species was obtained. The " regions " used here are those given in the " Station List " of the Expedition (Sewell, 1935*b*, p. 17).

It is apparent from the table that the Gulf of Aden is richest in species, but is fairly closely followed by the southern end of the Red Sea and the Zanzibar Area. The remaining areas have less than half the total number of species identified in the deposits, and are thus comparatively poor in species. Except for the Maldive Area, these areas poor in species of Pteropoda are all in the northern part of the Arabian Sea. This is also noticeable in the catches of living Pteropoda. Fewer species were caught in the northern region than from the western side of the Arabian Sea or from the Maldives.

As already stated in the opening paragraphs of this section, the amount of any group in the deposits fluctuates considerably in the upper 400 m., but falls off below this depth. This applies equally to the Pteropoda. Moreover, there is only a small percentage of Pteropod shells in shallow water of less than 150 m. depth. This is probably due to the action of currents, which move the other remains and the sand and grind up the delicate shells of the Pteropoda. Below 150 m. the numbers fluctuate greatly, being very high in Pteropod ooze and green Pteropod muds and low in other green muds. Below 400 m., however, the numbers seem to reach a constant value of rather less than 2% of the deposit—at least down to 700 m.

It is of interest to note that in the Zanzibar Area none of the Limacinidæ were found, nor were the Cavoliniid genera *Hyalocylis* and *Styliola*, but that all the other species listed above occurred at one or more stations.

The occurrence of large numbers of Pteropod shells in the southern part of the Red Sea and in the Gulf of Oman can be correlated with the movements of the several bodies of water in these areas.

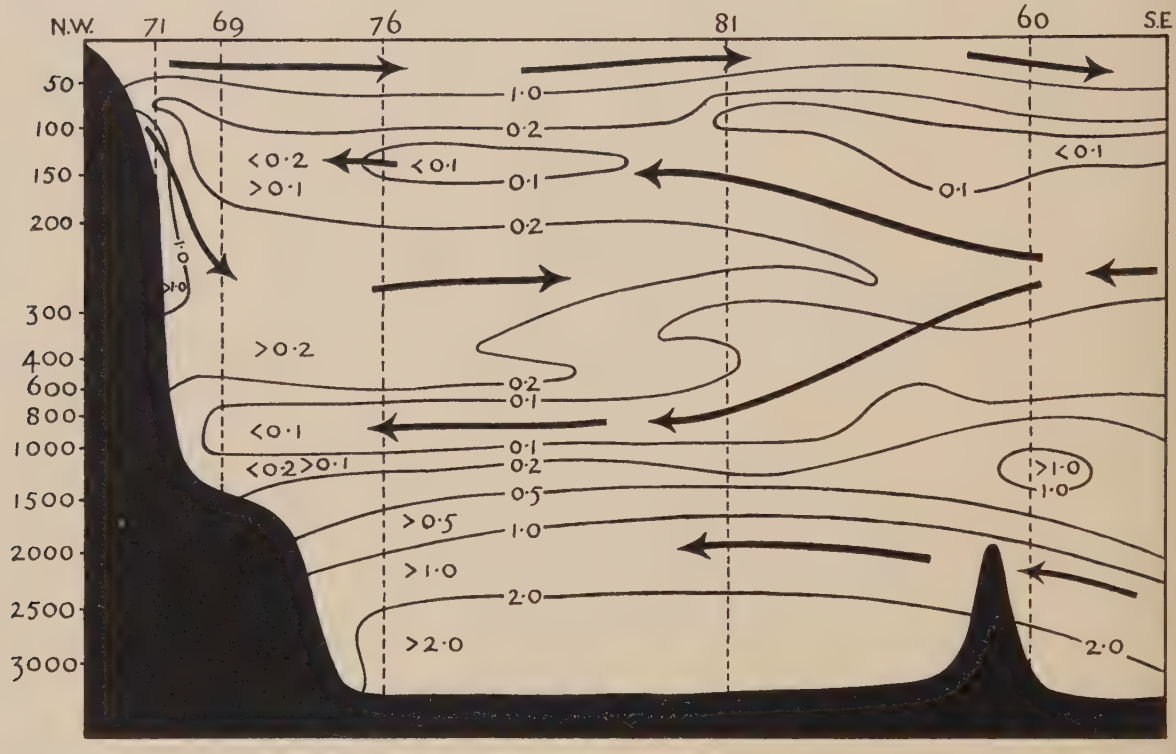
During the summer season there is an outflow of highly saline water, from the Red Sea, over the "sill", into the Gulf of Aden. This outflow is considerably diminished during the winter season, when there is a current of water flowing in the opposite direction. It is probably this Gulf of Aden water that carries the Pteropoda into the Red Sea, where they come into contact with the more saline and warmer Red Sea water, which proves fatal to them. Their shells sink down to form the deposit of Pteropod ooze met with on the north-west side of the "sill". Passing from the Gulf of Aden, over the "sill", into the Red Sea, the percentage of Pteropod shells in the deposit is at first negligible. At the highest point of the "sill" it is just measurable. On its north-west side it rises rapidly, and north of the "sill" reaches 8·0% of the deposit and over 60·0% of the total animal remains. Table XVII shows the available data for the occurrence of Pteropod shells in this region:

TABLE XVII.

Region.	Station.	Deposit.	Pteropod shells.	
			% deposit.	% remains.
Gulf of Aden	12	cs. s. sh.	..	..
SE. side of "sill"	9	r., s.	..	..
Top of "sill"	204	gn. m. Pt. sh.	0·4	1·5
NW. side of "sill"	7	s., Pt. sh.	..	16·9
	206	Pt. oz.	8·0	60·5
	207	Pt. oz.	8·1	65·4
Red Sea, north of "sill"	208	gn. m.	..	..
	209	calc. r., Pt. frags.	..	..

It is apparent, therefore, that large numbers of the Pteropoda are killed off on entering the Red Sea and meeting the more saline and warmer water. There is another patch of Pteropod ooze in the middle of the Red Sea, about Lat. 19° N., but none North of this.

The occurrence of Pteropod deposits in the Gulf of Oman can likewise be correlated with the mingling of masses of water of different temperature and salinity. The circulation here is rather similar to that in the Gulf of Aden. Four separate bodies of water occur, as shown in the accompanying figure (Text-fig. 5), which represents a longitudinal section of the Gulf of Oman. At the surface a stream of water of high salinity, temperature and oxygen-content derived from the Persian Gulf is flowing out of the Gulf of Oman. A second and lower body of Persian Gulf water, lying at a depth of 70 m. at the head of the



Text-fig. 5.—The circulation in the Gulf of Oman (after Thompson, unpublished).

Gulf, sinks to 300 m. and also moves out of the Gulf. This water has a high temperature and salinity and is at first moderately well oxygenated (>1·0 c.c. litre). It rapidly loses its oxygen, which off Muscat has fallen to 0·25 c.c. litre. Both these bodies of water swing to the right out of the Gulf of Oman and flow along close to the Arabian coast. Between them is a mass of poorly oxygenated water of low salinity flowing into the Gulf of Oman from the Arabian Sea. This appears to divide, some of it passing between the two layers of Persian Gulf water and some under the lower layer between it and the bottom water. The latter, lying below 1500 m., is comparatively highly oxygenated and of low salinity. Thus at all depths above 1500 m., except at the surface, the water is poorly oxygenated. Pelagic organisms are brought into the area by the surface Arabian Sea water which sinks below the outflowing Persian Gulf water. The deficiency in oxygen and the increased salinity met with in this Persian Gulf water cause the death of many of these organisms, especially the Pteropoda, whose remains sink down to accumulate in the deposit. The change in conditions

is probably not very abrupt, as no great number of Pteropoda are found in the deposits until the north-west end of the Gulf of Oman is reached. Here a small patch of Pteropod ooze occurs at Sta. 75. It is, of course, at this end of the Gulf that the difference between the inflowing and outflowing bodies of water is most marked.

The formation of Pteropod ooze on the Bombay shelf, recorded by the R.I.M.S. "Investigator", may also be due to a sudden change in the hydrographical conditions, perhaps here to a lowering of the salinity by the influx of fresh water from the Gulf of Cambay.

Along the African coast a similar fatal change in conditions is probably brought about by the upwelling of cold deeper water during the south-west monsoon.

(b) *Vertebrate Remains.*

Vertebrate remains were found at fifty-three stations, the most commonly occurring remains being fish otoliths, mainly of a uniform, very small size. Only occasionally were otoliths more than 5·0 mm. in length obtained. Otoliths occurred at forty-one of the fifty-three stations. Other Teleost remains were taken at a number of stations. Bones occurred in nineteen hauls and scales in nine. Among the latter, two hauls yielded triradiate spines, presumably scales of *Diodon* or a similar spinous form. Among the bones, vertebræ were commonest, ranging in size up to 24 mm. across the centrum. Other identifiable bones were ribs, opercular, dentary, premaxilla, maxilla and symplectic of various species. Of other fish remains, sharks' teeth occurred twelve times. These were mainly small teeth from the Priestman grab samples from comparatively shallow water—less than 400 m. No teeth coated with a thin layer of manganese, such as are figured by Murray and Renard (1891, pls. v–viii), were found, and no ear bones or beaks of whales. A few teeth, forming the nuclei of manganese nodules, were found at Sta. 166. The following genera of sharks* are represented, the figures in brackets indicate the number of teeth found :

Family Lamnidæ.
Isurus sp.
Sta. 54 (1).
Sta. 176 (1).
Sta. 193 (1).
Family Carcharinidæ.
Aprionodon sp.
Sta. 207 (2).
Scoliodon sp.
Sta. 56 (2).
Sta. 57 (2).
Sta. 207 (1).
Carcharinus sp.
Sta. 34 (1).
Sta. 56 (1).
Sta. 57 (2).
Sta. 59 (1).
Sta. 86 (3).
Sta. 176 (3).
Sta. 207 (2).
? *Carcharinus* sp.
Sta. 75 (1).
Sta. 89 (1).
Sta. 179b (1).

In addition a Teleost tooth, probably of a species of *Evermannella*, was identified from Sta. 78.

Other remains include a large egg-case of a species of ray from Sta. 120 and a turtle scale from Sta. 153.

* Identifications by Mr. J. R. Norman, Brit. Mus. (Nat. Hist.).

The more commonly occurring remains, otoliths, bones, scales and sharks' teeth have similar depth ranges. The following are the extremes of depth recorded for each type of remains :

Otoliths (31, 37), 91–2312 m. Scales 201–1061 m.
Bones (37), 102–1269 m. Sharks' teeth, 101–3351 m.

The figures in brackets indicate the depths at which the remains were found in the lagoons of the Maldive Archipelago. The wide depth range of otoliths is in agreement with Murray's conclusion (1891, pp. 267–8) that these are the most resistant of the calcareous structures of fish, but he does not record scales from any of the materials of the " Challenger " expedition. Bones, other than beaks and ear-bones of whales, were only obtained on three occasions. On the other hand he records teeth as " exceptionally abundant " in the pelagic deposits, especially in red clay, whereas at no station in the north-west Indian Ocean were sharks' teeth very common and none were obtained from red clay, the chief source of those obtained by the " Challenger ", except those forming the nuclei of manganese nodules. Agassiz (1888, p. 281) comments on the unusual number of otoliths found in deposits from the Gulf of Mexico in depths from 392–1568 fms. (725–2900 m.). Fish teeth also occurred here in some deposits from over 500 fms. (925 m.).

(c) *Siliceous Remains.*

(c. i) *Porifera.*—Siliceous remains are rather rare in the deposits and consist of Diatoms, fragments of sponge spicules and Radiolaria. Sponge spicules occurred most frequently, being found at thirty-three stations. At Sta. 175 only were they abundant in green calcareous mud from 1618 m. At three other stations spicule fragments were fairly common, as follows :

Station.	Depth (m.).	Deposit.
119	1204	lt. br. clayey, gl. oz.
135	2727	gl. oz.
152	878	gy. m.

Fragments of Poriferan skeletons were only of rare occurrence at the remaining twenty-nine stations. The rarity of sponge spicules may be due to the physical state of the silica. According to Pirrson (1920, p. 433) this is in the colloidal form, and is readily destroyed during organic decay and seldom preserved as a fossil. He says that Radiolaria and Diatoms, however, are composed of silica in an insoluble form and are rarely destroyed. Nevertheless, Radiolaria and Diatom frustules are by no means as common as siliceous sponge spicules in the deposits. Sponge spicules are present over a wide depth range, as the following figures show :

Metres.	No. of records.	Metres.	No. of records.
0–500	5	3000–4000	2
500–1000	5	4000–5000	5
1000–2000	8	Over 5000	1
2000–3000	7		

It is noticeable that most of the records occur at the mouth of the Gulf of Aden or in the Zanzibar region and very few in the open sea.

(c.ii) *Radiolaria.*—Radiolaria were identified in sediments from nineteen stations, ranging in depth from 1173–4499 m. The distribution in depth is shown below :

Metres.	No. of records.	Metres.	No. of records.
0–1000	..	3000–4000	2
1000–2000	6	4000–5000	6
2000–3000	5		

Radiolaria appear to be entirely absent from the shallower deposits. In those from below 1000 m. they occur very sparingly. At no station were they found in sufficient numbers to form a deposit that could be called Radiolarian ooze ; even in the South Somali Basin, in which Murray and Philippi (1908, p. 167) record a large area of the bottom as covered with Radiolarian ooze, none were obtained. There are no Radiolaria in the pure red clay obtained in the Arabian Basin at Sta. 166, though a few were found in the transitional Globigerina ooze from the next station, Sta. 167.

It is of interest that no less than nine of the records of Radiolaria lie in or about the mouth of the Gulf of Aden and only one in the western part of the Gulf. The other nine records are scattered about the southern and central regions of the Arabian Sea. No records come from the Oman Basin, and only two from the extreme southern border of the Arabian Basin, one (Sta. 167) near the Carlsberg Ridge and the other (Sta. 135) on the western slope of the Maldive ridge.

(c.iii) *Diatoms.*—Diatom frustules were found in the sediments from fifteen stations dotted about the Arabian Sea. Like the other siliceous remains diatoms are not generally common, but in several places they are abundant. Thus, off the mouth of the Gulf of Aden, Diatom frustules were quite common at Stas. 22, 39 and 175, and off Ras al Hadd were abundant in green mud from Stas. 55 and 56. The Diatoms from these two stations were all of one species, the large circular *Coscinodiscus oculis-iridis* var. *borealis* (Bail.), Cl. Fragments of this or other *Coscinodiscus* spp. were the chief forms present at most of the other thirteen stations where diatom frustules were found. At the remaining ten stations Diatoms were very rare.

Diatom remains occur more frequently on the western side of the Arabian Sea than elsewhere as the following figures show :

African and Arabian coastal regions.	Central Arabian Sea.	Eastern Arabian Sea.
11 Stas.	1 Sta.	3 Stas.

As already stated (p. 120), *Coscinodiscus* spp. occur abundantly in the surface waters of the northern Indian Ocean. The more frequent occurrence of these diatoms in the deposits on the western side of the Arabian Sea can probably be correlated with increased productivity due to the transport of nutrient salts to the surface by upwelling water along the African and Arabian coasts during the south-west monsoon.

(d) *Bottom-living Mollusca.*

The bottom-living Mollusca are represented in the sediments by shells and shell-fragments of Gasteropoda, Lamellibranchiata and Scaphopoda. The last, however, are

rather rare and usually negligible as components of the sediments. They were found in only fourteen samples. Table XVIII gives an idea of the relative importance of the three groups of Mollusca as components of the sediments :

TABLE XVIII.

	Gasteropoda.	Lamellibranchiata.	Scaphopoda.
Number of records.	67.	60.	14.
Maximum % of lagoon sediments	21·4	13·5	..
Average % of lagoon sediments	6·4 (9 Stas.)	4·0 (9 Stas.)	..
Maximum % in deep water	16·0	30·0	2·6
Average % in deep water	3·9 (24 Stas.)*	4·8 (23 Stas.)*	0·8 (12 Stas.)*
Average % in deep water (excluding abnormal values)	2·8	2·1	0·8

* Incomplete samples or negligible quantities made averaging impossible at the other stations.

The above table indicates that generally the Gasteropoda and Lamellibranchiata contribute about equally to the deposit. Either, however, may be entirely absent or vastly in excess of the other, attaining as much as 15–20% of the deposit (Gasteropoda) or even 30% (Lamellibranchiata). The contributory value of each group varies in the lagoons and in deep water. Comparing the two more important groups, Gasteropoda and Lamellibranchiata, these contribute about equally to the deep-water deposits. In the lagoons, however, the Gasteropoda apparently contribute about half as much again as the Lamellibranchiata. Although both Gasteropoda and Lamellibranchiata are generally present, the actual percentage contributed by either to the deposit is usually low. The deposits from the following stations only contained more than 5% of shells :

Stations with 5% or more of—	
Lamellibranchiata.	Gasteropoda.
28 . 142a	28 . 142a . 178
72 . 144	73 . 144 . 189
73 . 189	75 . 163 . 190
103 . 190	139 . 164 . ..

These stations occur in groups in several parts of the Arabian Sea. Stas. 72, 73 and 75 are all at the north-western end of the Gulf of Oman ; Stas. 28, 178, 189 and 190 are in the Gulf of Aden ; Stas. 139, 142a, 144, 163 and 164 in the Maldive Archipelago ; and Sta. 103 off Zanzibar. These four regions appear to be the most prolific as regards the production of Mollusca.

The Gasteropoda appear to contribute their maximum to the sediments in the lagoons, where the sands may contain large quantities of Gasteropod fragments. In deeper water the amount falls to only about three-fourths of this. The Lamellibranchiata, on the other hand, show the reverse. In deep water they may form large banks of shells or shells with mud, in which the shells may exceptionally form 30% of the deposit. But in the lagoons the

bivalve portion falls to less than half of this value, the maximum found in the Maldive samples being only 13·5%, as compared with 30·0% for the open waters of the Arabian Sea.

All three groups of Mollusca are most abundant in depths from 200–300 m. ,though they extend over varying depth ranges. Table XIX shows the depth range of the three groups as deduced from the depths from which the sediments containing them were obtained:

Table XIX.

Depth (m.)	Number of times obtained.		
	Gasteropoda.	Lamellibranchiata.	Scaphopoda.
0–100	6	5	2
100–200	8	8	2
200–300	17	16	5
300–400	9	7	2
400–500	2	3	..
500–600	1	2	1
600–700	2	2	2
700–800	2	..	..
800–900	1	1	..
900–1000	1	..	..
1000–1100	1	..	..
1100–1200	2	1	..
1200–1300	1	4	..
↓	↓	↓	↓
2300–2400	1	1	..
↓	↓	↓	↓
3300–3400	1	1	..

It is apparent from the above figures that the Gasteropoda and Lamellibranchiata have much the same bathymetrical range, whereas the Scaphopoda are confined to lesser depths. The maximum occurrence about 200–300 m. is in agreement with the results obtained for the depth distribution of the living Mollusca taken in the grab, namely 160–240 m. (see Text-fig. 3, p. 123).

In most localities the shell remains are much broken and consist of fragments of numerous species. At several stations, however, the shells are almost entirely of one species, At Stas. 180, 190 and 191 the shell component was almost exclusively formed of valves of the Lamellibranch *Venus torresiana* (Smith). This shell was also present in the deposit at Stas. 28, 178, 179b and 192, where, however, it was much less common. Large numbers of the valves had a small round hole bored through them, presumably by a carnivorous Gasteropod.

The size of these valves is fairly uniform. At Sta. 191 most are about 13 m. long, which is nearly the largest size found at any station. At Sta. 180 several sizes of shell are common, These sizes are intermediate between those found at Sta. 191, and those at Sta. 190 where all are rather small, between 7 and 8 mm. long. The presence of a standard size of shell seems to indicate that the bivalves are in most cases killed off *en masse* by unfavourable

conditions rather than by predatory animals. This is borne out by the small number of bored valves, amounting to only about 13·6% of the living animals. Among the small shells from Sta. 190 very few are bored, equivalent to only about 15·2% of the living animals. It is, of course, possible that a plague of predatory animals such as Asteroids may have caused the wholesale destruction of an age-group of the mollusca.

In the case of the mixed sizes of shells from Sta. 180, the bored valves are equivalent to 74% of the living animals, leaving only 26% that have presumably been killed by animals other than boring Gasteropoda or have died from other causes. It seems that the carnivorous Gasteropoda are the chief agents in killing off the Lamellibranchiata, accounting for almost three times as many as are killed by other means at this station.

(e) *Foraminifera.*

Tests of Foraminifera occur in practically all the deposits examined. Close on 300 species and a few varieties have been identified, of which only sixteen species are pelagic. As a general rule the benthic species are commonest in relatively shallow water, i. e. the zone of green mud and sand and the lagoons and slopes of the atolls, though a number occur in the deep water deposits. The pelagic species are commonest in Globigerina ooze, in which the lack of variety is made up for by the great abundance of individual species, *e. g. Globigerina bulloides* and *Globorotalia menardii*. Pelagic species occur in the shallow water deposits, but in smaller numbers. Where the Globigerina ooze passes into green mud, pelagic Foraminifera are common. As the depth at which the green mud lies decreases the number of pelagic specimens decreases, until finally, in the sandy green muds from 100 m. or less, only occasional isolated tests of *Globigerina* may be found.

The tabular summary of the deposit-types in Section IV (Table XIII, p. 140) shows the number of species in each of the deposits. The Foraminiferal faunas of the several deposits have been given in that section and need not be repeated. The following table (Table XX) shows the numbers of species in each deposit that also occur in each of the others.

Comparing the numbers of species found in each deposit, it is obvious that the green muds are the zone in which species production has been most active. More than twice as many species occurred in this deposit as in any other.

Apart from the grey clay, in which the number of species and specimens is very low, the percentage of species peculiar to each deposit is relatively constant, varying from 16·7% in Pteropod ooze to 35·4% in green mud. The greatest number of indigenous species occurs in green mud, which deposit contains by far the most abundant Foraminiferal fauna. Owing to this great abundance, 50–70% of the species found in the other deposits are found here. The actual valves found are shown in Table XX. The number of species common to any two deposits is further increased by the fact that there is no definite line of demarcation between the deposits, which pass into one another, so that some species may be assigned equally to two or more deposit types.

It is noteworthy that the green muds have the greatest number of species in common with the deposits on the slopes of the Maldive atolls, almost 70% of the species found in the " slope " deposits occurring in the terrigenous muds. Apparently depth is a more potent factor in determining the distribution of the species than the type of deposit.

It has already been seen that the Pteropod ooze in the Arabian Sea lies in the transition zone between green mud and Globigerina ooze. The Foraminiferal fauna reflects this :

Table XX.

The Interrelationship of the Foraminiferal Faunas of the Deposits.

Deposit.	Number of spp.	Number and % of spp. peculiar to deposit.	Number and % of species occurring in other deposits.								
			Grey clay.	Grey mud.	Green mud.	Terrigenous sand.	Globigerina ooze.	Pteropod ooze.	Lagoon mud.	Lagoon sand.	Reef slopes.
Grey clay . . .	8	0 0%	..	1 12·5%	5 62·5%	1 12·5%	2 25·0%	6 75·%	0 0%	0 0%	3 37·5%
Grey mud . . .	28	8 28·5%	1 3·6%	.. ..	17 60·7%	6 21·4%	11 39·2%	3 10·7%	1 3·6%	0 0%	6 21·4%
Green mud . . .	192	68 35·4%	5 2·6%	17 8·8%	.. ..	48 25·0%	36 18·7%	41 21·3%	15 7·8%	18 9·3%	55 28·6%
Terrigenous sand . .	86	28 32·5%	1 1·2%	6 7·0%	48 55·8%	.. ..	12 14·0%	17 19·7%	10 11·6%	17 19·7%	34 39·4%
Globigerina ooze . .	61	20 32·7%	2 3·3%	11 18·0%	36 59·0%	12 19·6%	.. ..	8 13·1%	2 3·3%	2 3·3%	17 27·9%
Pteropod ooze . .	60	10 16·7%	6 10·0%	3 5·0%	41 68·3%	17 28·3%	8 13·3%	.. ..	7 11·6%	6 10·0%	15 25·0%
Lagoon mud . .	28	5 17·8%	0 0%	1 3·6%	15 53·5%	10 35·7%	2 7·1%	7 25·0%	.. ..	10 35·7%	14 50·0%
Lagoon sand . .	36	8 22·2%	0 0%	0 0%	18 50·0%	17 47·2%	2 5·5%	6 16·6%	10 27·7%	.. ..	24 66·6%
Outer Reef slope deposits	80	14 17·5%	3 3·75%	6 7·5%	55 68·8%	34 42·5%	17 21·3%	15 18·75%	14 17·5%	24 30·0%	.. ..

68·3% of the Pteropod ooze species are identical with green mud species. In the Globigerina ooze the percentage in common has fallen to 59.

Very little can be deduced as regards the distribution of individual species, since the majority occurred only once or twice and usually in very small numbers. An idea of this paucity of records can be gathered from the table of species present in green mud (Table V, p. 116). Most of the species listed there occurred only once or twice. The same applies equally to the other deposits. At two stations only was a species taken in really large numbers. *Rhabdammina abyssorum* M. Sars was found at seven stations as follows :

Sta. 50, Arabian coast,
Stas. 26, 185, 188, Gulf of Aden.
Stas. 109, 119, 120, Zanzibar Area.

At Stas. 120 and 185 the variety *radiata* Cushman occurred with the typical form. At six of these stations the species was not common, but at Sta. 185 it was exceedingly abundant. The residue left after washing out the mud from a sample of the deposit consisted almost entirely of fragments of the tests of *Rhabdammina* (see Pl. IV, fig. 2).

At Sta. 105, in the Zanzibar Area, a second arenaceous species, *Dendrophrya ramosa* Cushman, was obtained in equally large numbers. The washed residue again consisted almost entirely of the one species (see Pl. IV, fig. 1). This species was only obtained once more, at Sta. 119, also in the Zanzibar Area.

Presumably the species in both instances has met with optimum environmental conditions. The factor permitting this great development is probably the nature of the bottom. The deposit, though still referable to the same deposit-type, may vary considerably in texture and value as a source of food over small distances. The hydrographical conditions, on the other hand, are relatively stable over much larger areas, and so are unlikely to be the major factor in controlling the development of these " Foraminifera-beds ".

VI. SUMMARY.

1. 185 samples of deposits from 131 stations in the Arabian Sea are described. The distribution of the main types of Marine Deposits in the Arabian Sea is determined from earlier charts and these new materials. The transitional Globigerina ooze/red clay deposit is indicated separately on the new chart, as this mixed deposit is frequently difficult to assign to one or the other of its component types.

The extent of the various deposits in the region of Zanzibar is shown in detail on a separate chart and is discussed. The distribution of the pelagic deposits here is correlated with water movements.

2. The remains of organisms in the deposits have been separated out, and the percentage of remains of each of the commoner phyla determined. The total percentage of remains in the deposits is correlated with the depth, being high in shallow water, low in 500–600 m. and then rising again in about 1000 m. This rise is mainly due to the accumulation of *Globigerina* and other pelagic Foraminiferal shells at this depth. The Foraminifera and Pteropoda are identified. Other organisms are only classed into the appropriate phylum or order or occasionally genus.

3. The samples of deposits and their contained animals collected with the Priestman grab are discussed at length. The shallow-water samples from the lagoons of the Maldive Archipelago are considered separately. There is a steady falling off in the density of the

population as the depth in the lagoon increases. The zonation of the fauna on the Continental Shelf, described by Alcock off the Ganjam coast, is present in the Arabian Sea.

4. The depth range of the animals obtained by the grab is discussed. Lamellibranchiata, Gasteropoda, Ophiuroidea, Prawns, *Upogebia* sp., Corals and Polychæta all have a large vertical range. The greatest number of forms occurred in 160–240 m. This depth is in agreement with that given by Alcock. This is the " mud-line " of Murray.

5. The different types of deposit are reviewed as animal habitats in the light of the grab hauls. Green muds are rich life areas ; grey muds and clays and light-brown or yellow muds are almost azoic. Muds and sands from the lagoons are rich in life. Continental sandy deposits support fewer animals than deposits of similar texture from the Maldive lagoons. The occurrence of different groups on terrigenous muds and sands and the muds and sands of the Maldives is tabulated. Certain groups are clearly shown to live mainly or exclusively on the coarser deposits.

6. The distribution of Pteropoda, Vertebrate remains, Siliceous organisms, bottom-living Mollusca and Foraminifera is discussed. The distribution of Pteropod deposits is correlated with peculiarities in the hydrographical conditions.

The relationships of the benthic Foraminiferal faunas of the various deposit types are discussed in general terms. Green and brown muds have the largest Foraminiferal fauna. Over 50% of the species present in Pteropod ooze and Globigerina ooze are found in these deposits. The numbers and percentages of species common to any two deposits and those peculiar to each deposit are tabulated.

LIST OF REFERENCES.

Admiralty Pilot, no. 29, African Pilot III, East coast of Africa. . . . 9th ed., 1929, pp. i–xxxi, 1–515.

Agassiz, A. 1888. Three Cruises of the " Blake ", I, pp. i–xxii, 1–314, figs. a–e, 1–194, Cambridge, Mass.

—— 1892. Reports on the Dredging Operations off the West Coast of Central America to the Galapagos . . . II. Bull. Mus. Comp. Zool. Harv. XXIII, no, 1, pp. 1–89, pls. i–xxii.

Alcock, A. 1890. On some Undescribed Shore-fishes from the Bay of Bengal. Ann. Mag. Nat. Hist. 6, VI, pp. 425–443, text-figs. 1–3.

Crossland, C. 1902. The Coral Reefs of Zanzibar. Proc. Camb. Phil. Soc. XI, no. 6, pp. 493–503, pl. vi.

Cushman, J. A. 1933. Foraminifera, their Classification and Economic Use, 2nd ed., Special Publ. Cushman Lab. no. 4.

—— 1933. An Illustrated Key to the Genera of Foraminifera, Special Publ. Cushman Lab. no. 5.

Farquharson, W. I. 1936. Topography, with an Appendix on Magnetic Observations. Sci. Repts. " John Murray " Exped. I, 2, pp. 43–61, pls. i–vi, 6 charts.

Hanzawa, S. 1928. Preliminary Report on marine deposits from the North Pacific Ocean. Rec. Oceanogr. Wks. Jap. I, no. 2, pp. 59–77, pls. xvi–xxi.

—— 1935. Diatom (*Ethmodiscus*) ooze obtained from the Tropical South-western North Pacific Ocean. Rec. Oceanogr. Wks. Jap. VII, pp. 37–44, pls. i–ii.

Hesse, R. 1924. Tiergeographie auf ökologischer Grundlage, pp. i–xii, 1–613, text-figs. 1–135. Jena.

Hornell, J., and Nayudu, M. R. 1924. Contribution to the Life-history of the Indian Sardine. Madras Fish. Bull. XVII, rept. 5, pp. 129–197.

Kemp, S., Hardy, A. C., and Macintosh, N. A. 1929. Objects, Equipment and Methods. Discovery Repts. I, pp. 143–232, pls. vii–xviii.

Menon, K. S. 1931. A Preliminary Account of the Madras Plankton. Rec. Indian Mus. XXXIII, pp. 489–516, figs. 1–4, pls. ix–xv.

Murray, J. 1899. On the Marine Deposits in the Indian, Southern and Antarctic Oceans. Scot. Geogr. Mag. V, pp. 405–436, 1 chart.

—— 1909. On the Depths and Marine Deposits of the Indian Ocean. . . . Rep. Percy Sladen Trust Exped. to the Indian Ocean 1905, II, no. 13, pp. 355–396, pls. xxii–xxiv.

Murray, J., and Lee, G. V. 1909. The Depths and Marine Deposits of the Pacific. Mem. Harv. Mus. Comp. Zool. XXXVIII, pp. 1–169, pls. i–v, maps i–iii.

—— and Philippi, E. 1908. Die Grundproben der Deutschen Tiefsee-Expedition. Wiss. Ergebn. d. Deutschen Tiefsee-Exped. X, pp. 80–206, pls. xvi–xxii, 2 maps.

—— and Renard, A. F. 1891. Deep Sea Deposits. Rep. Sci. Res. . . . H.M.S. " Challenger " Exped. pp. i–xxix, 1–525, figs. 1–36, pls. i–xxix, charts 1–43.

Petersen, C. G. J. 1914. Valuation of the Sea. II: The Animal Communities of the Sea Bottom and their Importance for Marine Zoogeography. Rep. Danish Biol. Sta. XXI, 1913, pp. 1–44 and app. 1–68, pls. i–vi, charts i–iii.

Pirsson, L. V., and Schuchert, C. 1920. A Textbook of Geology, ed. 2, pt. I (by L. V. Pirsson), pp. i–vi, 1–470, text-figs. 1–311, M_1–M_6.

Schmelck, L. 1882. On Oceanic Deposits. Norske Nordhavs Exped. 1876–78, IX. Chemistry, II, pp. 1–71, 1 text-fig., 2 maps.

Schmidt, J. 1932. Dana's Togt omkring Jorden 1928–1930, pp. 1–368, text-figs. 1–278, 1 chart. Copenhagen.

Sewell, R. B. S., 1925. Geog. and Oceanog. Research in Indian Waters, 2. A Study of the Nature of the Sea-bed and of the Deep-sea Deposits of the Andaman Sea and Bay of Bengal. Mem. Asiat. Soc. Bengal, IX, 2, pp. 27–50, text-fig. 4, pl. vi.

—— 1935*a*. Geog. and Oceanog. Research in Indian Waters: 7. The Topography and Bottom Deposits of the Laccadive Sea. Mem. Asiat. Soc. Bengal, IX, 7, pp. 425–460, text-figs. 133–135, pls. ix, x.

—— 1935*b*. Introduction and List of Stations. Sci. Repts. " John Murray " Exped. I, 1, pp. 1–41, 1 chart.

Thalmann, H. E. 1932. Nomenclator (Um- und Neu-benennung) zu den Tafeln 1 bis 115 in H. B. Brady's Werk über die Foraminiferen der Challenger-Expedition, London, 1884. Eclog. Geol. Helv. XXV, pp. 293–312.

Wiseman, J. D. H., and Sewell, R. B. S. 1937. The Floor of the Arabian Sea. Geol. Mag. Lond. LXXIV, pp. 219–230, text-figs. 1–3, pl. xi.

Wüst, G. 1936. Die Gliederung des Weltmeeres. Petermanns Mitt. LXXXII, pp. 33–38, pl. i.

DESCRIPTION OF PLATE I.

1. Grey Mud : Sta. 85, off Bombay, × 15.
    1. *Globigerina bulloides* d'Orbigny.
    2. *Globigerinoides sacculifera* (Brady).
    3. *Orbulina universa* d'Orbigny.
    4. *Pulleniatina obliquiloculata* (Parker and Jones).
    5. *Globorotalia menardii* (d'Orbigny).
    6. *Trochammina globigeriniformis* (Parker and Jones).
    7. Otolith.
    8. Mud lumps.

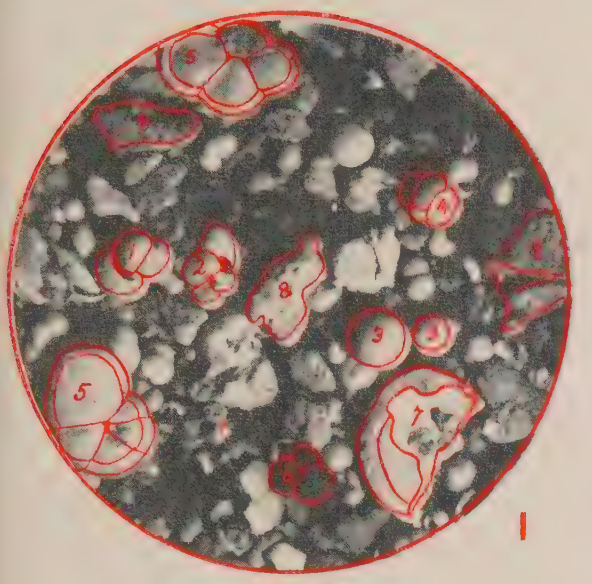
2. Green Mud from shallow water : Sta. 74, Gulf of Oman, × 1.
    1. *Creseis acicula* Rang.
    2. *Cr. virgula* Rang.
    3. *Diacria quadridentata* (Lesueur).
    4. *Cavolinia longirostris* (Lesueur).
    5. Coral fragment.
    6. Polychæt tubes.
    7. Polyzoa.
    8. Echinoderm fragments.
    9. Crustacean fragments.
    10. Lamellibranchiata.
    11. Gasteropoda.

3. Green Mud from deep water : Sta. 20, Gulf of Aden, × 15.
    1. *Globigerina bulloides* d'Orbigny.
    2. *Gl. dubia* Egger.
    3. *Globorotalia menardii* (d'Orbigny).
    4. *Pyrgo depressa* (d'Orbigny).
    5. *Creseis acicula* Rang.
    6. Otolith.
    7. Fæcal pellets.

4. Fæcal pellets from Green Mud : Sta. 18, Gulf of Aden, × 15.
    1. *Globigerina bulloides* d'Orbigny.
    2. *Globorotalia canariensis* (d'Orbigny).
    3. *Uvigerina* sp.
    4. Fæcal pellets.

5. Diatomaceous Green Mud : Sta. 55, off Ras al Hadd, × 15.
    1. *Creseis acicula* Rang.
    2. *Coscinodiscus oculis-iridis* var. *borealis* (Bail.) Cl.
    3. *Globigerina bulloides* d'Orbigny.

6. *Coscinodiscus oculis-iridis* var. *borealis* (Bail.) Cl. Specimens × *c.* 65.



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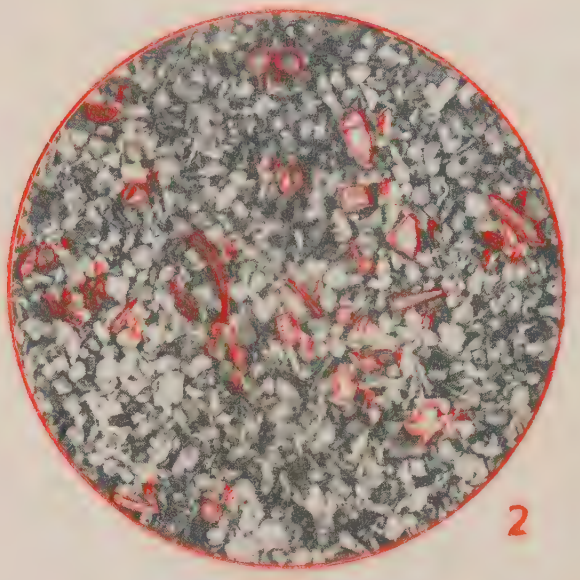

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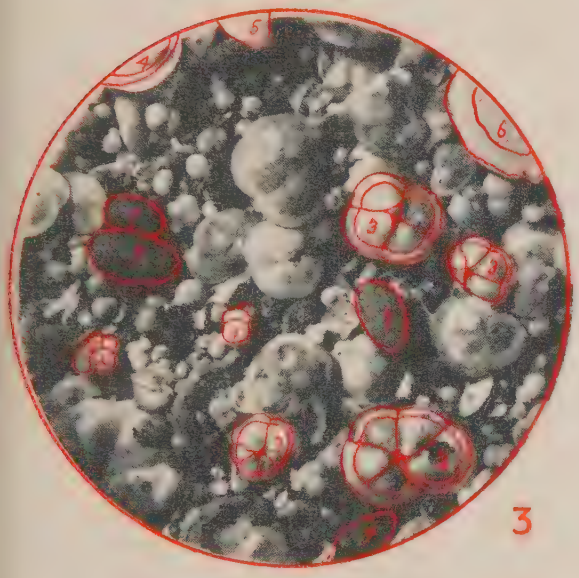

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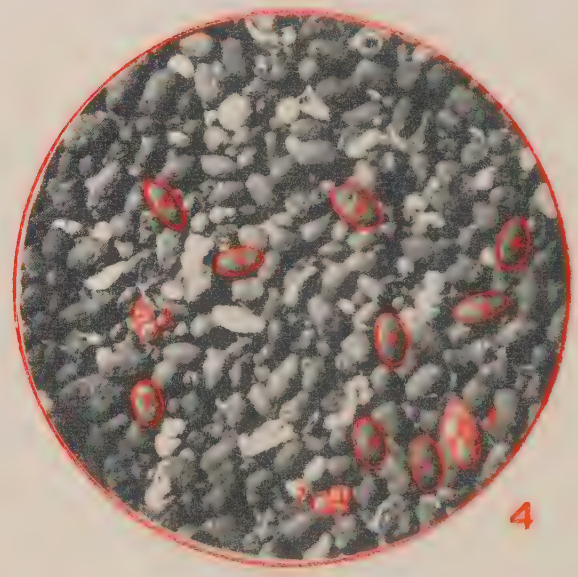

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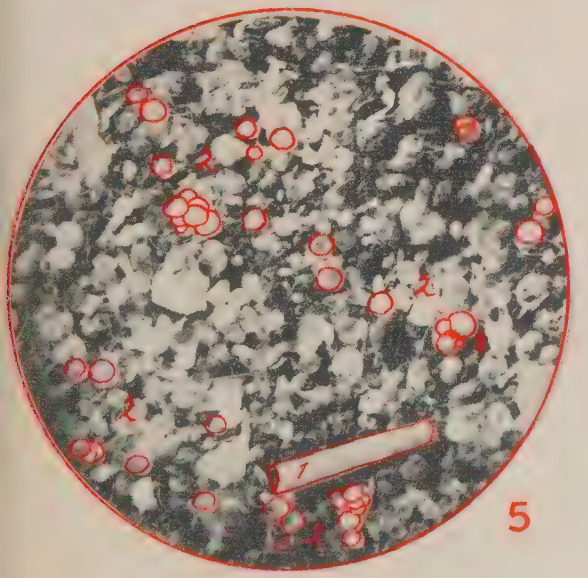

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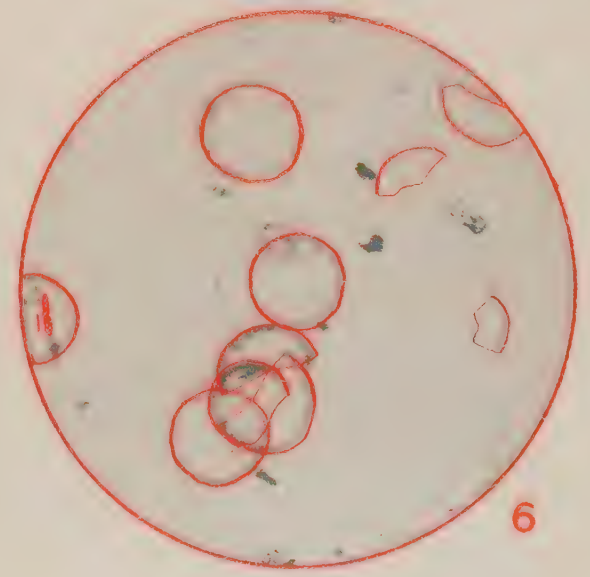

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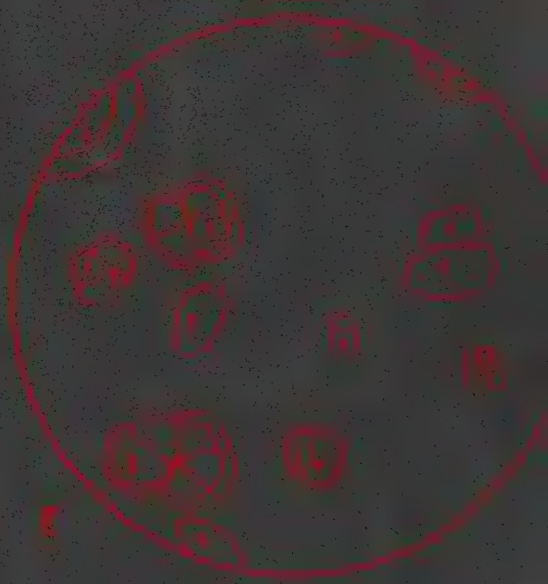

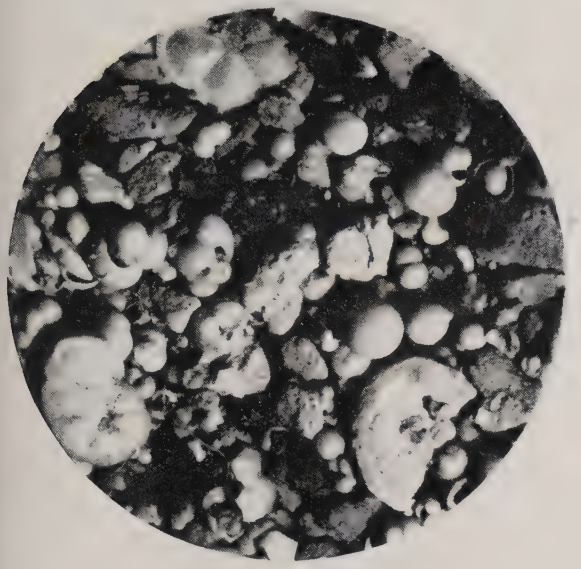

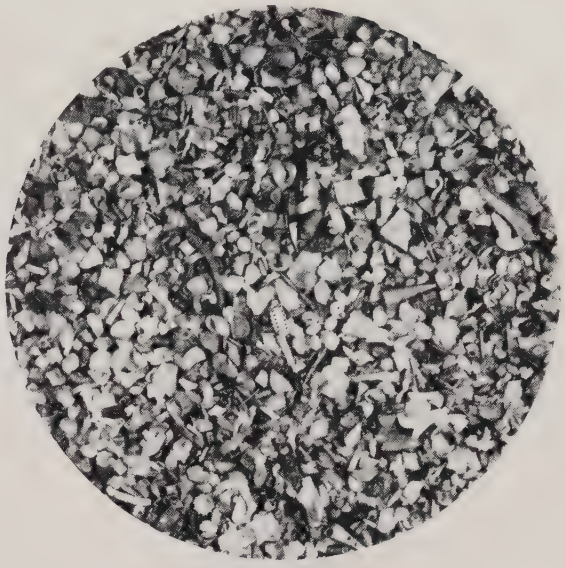

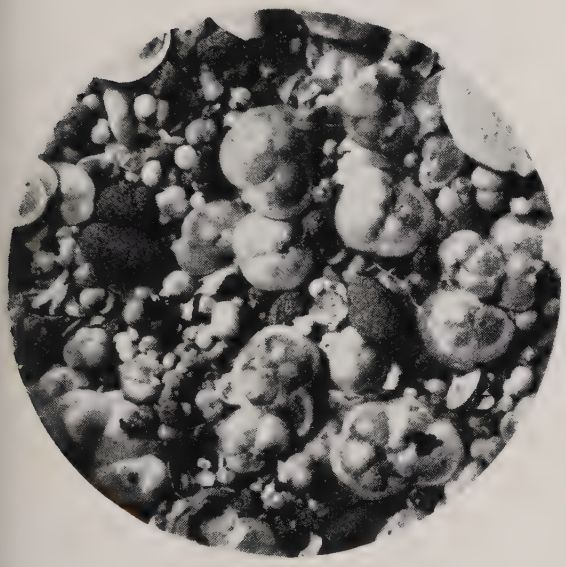

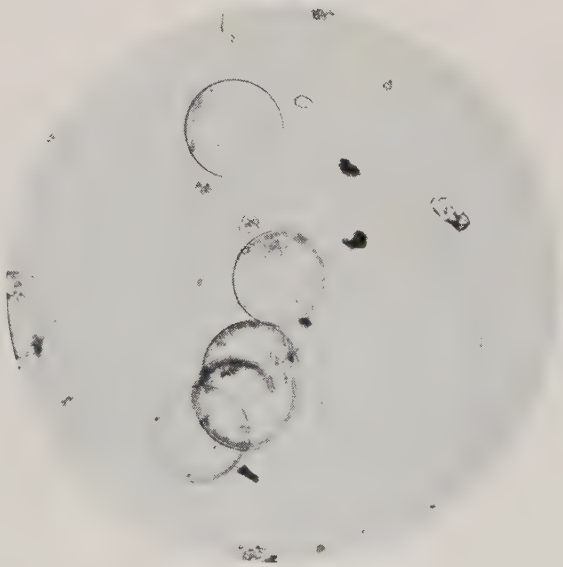

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DESCRIPTION OF PLATE II.

1. Foraminifera from Green Mud : Sta. 190, Gulf of Aden, × 15.
    1. *Uvigerina pygmæa* d'Orbigny.
    2. *Uvigerina* sp.
    3. Miliolid sp.
    4. *Nonion boueanum* (d'Orbigny).
    5. *Globigerina bulloides* d'Orbigny.

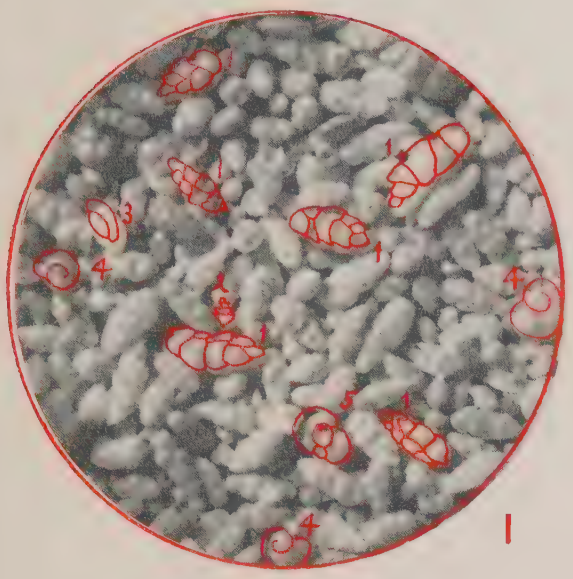
2. Calcareous Terrigenous Sand : Sta. 178, Gulf of Aden, × 1.
    1. Lamellibranch valve.
    2. Gasteropod fragment.
    3. Echinoderm fragments.
    4. Crustacean fragment.
    5. Cirriped valves.
    6. *Heterostegina* sp.
    7. Poriferan spicule.

3. Calcareous-Siliceous Sand : Sta. 103, off Zanzibar Island, × 1.
    1. Lamellibranch valves.
    2. Gasteropod fragments.
    3. Echinoderm fragment.
    4. *Nodosaria* sp.
    5. Solitary Coral.
    6. Pteropod shells.
    7. Polyzoa.
    8. Scaphopod shell.
    9. *Miniacina miniacea* (Pallas).

4. Siliceous Sand : Sta. 113, between Pemba Island and Mainland, × 1.
    1. Lamellibranch valves.
    2. Pteropod shells.
    3. Foraminiferan, *Heterostegina* sp.
    4. Crustacean fragment.

5. Globigerina Ooze : Sta. 60, Northern Arabian Sea, × 15.
    1. *Orbulina universa* d'Orbigny.
    2. *Globorotalia menardii* (d'Orbigny).
    3. *Pulleniatina obliquiloculata* (Parker and Jones).
    4. *Sphæroidinella dehiscens* (Parker and Jones).
    5. *Globigerina bulloides* d'Orbigny.
    6. *Gl. dubia* Egger.
    7. *Globigerinoides sacculifera* (Brady).

6. Globigerina Ooze : Sta. 167, Central Arabian Sea, × 15.
    1. *Orbulina universa* d'Orbigny.
    2. *Globorotalia menardii* (d'Orbigny).
    3. *Gl. tumida* (Brady).
    4. *Sphæroidinella dehiscens* (Parker and Jones).



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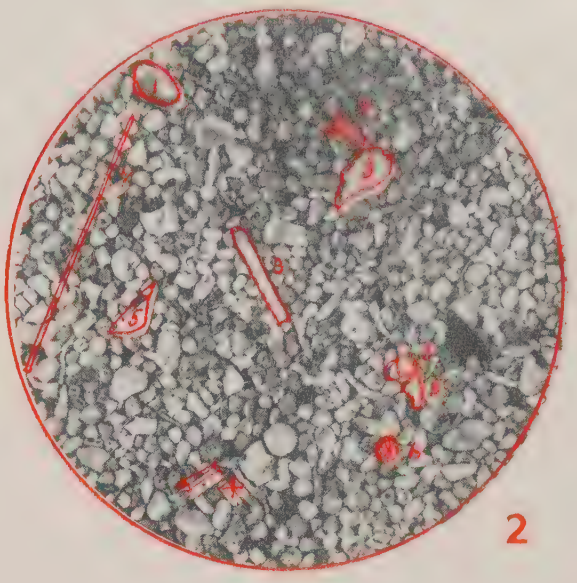

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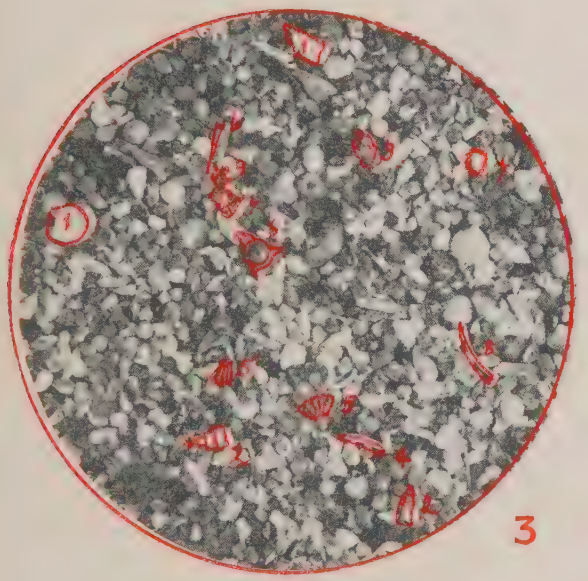

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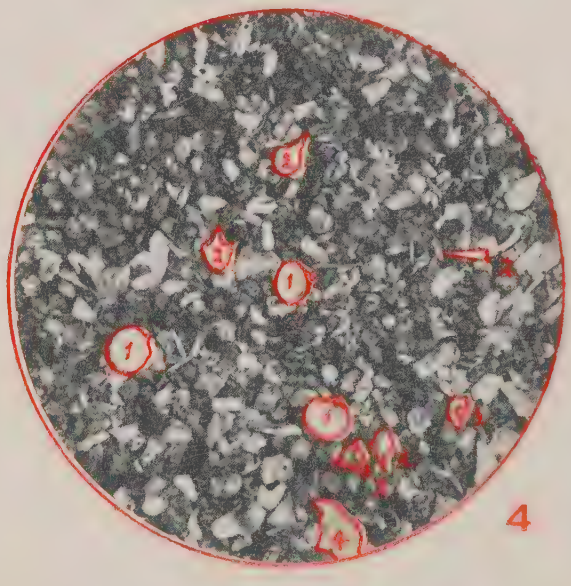

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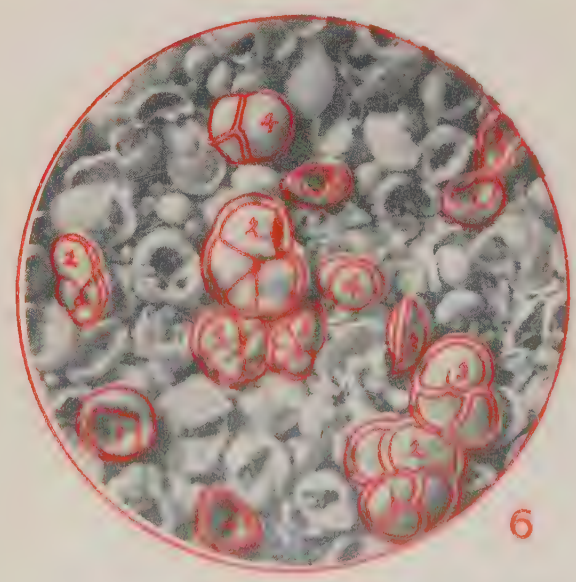

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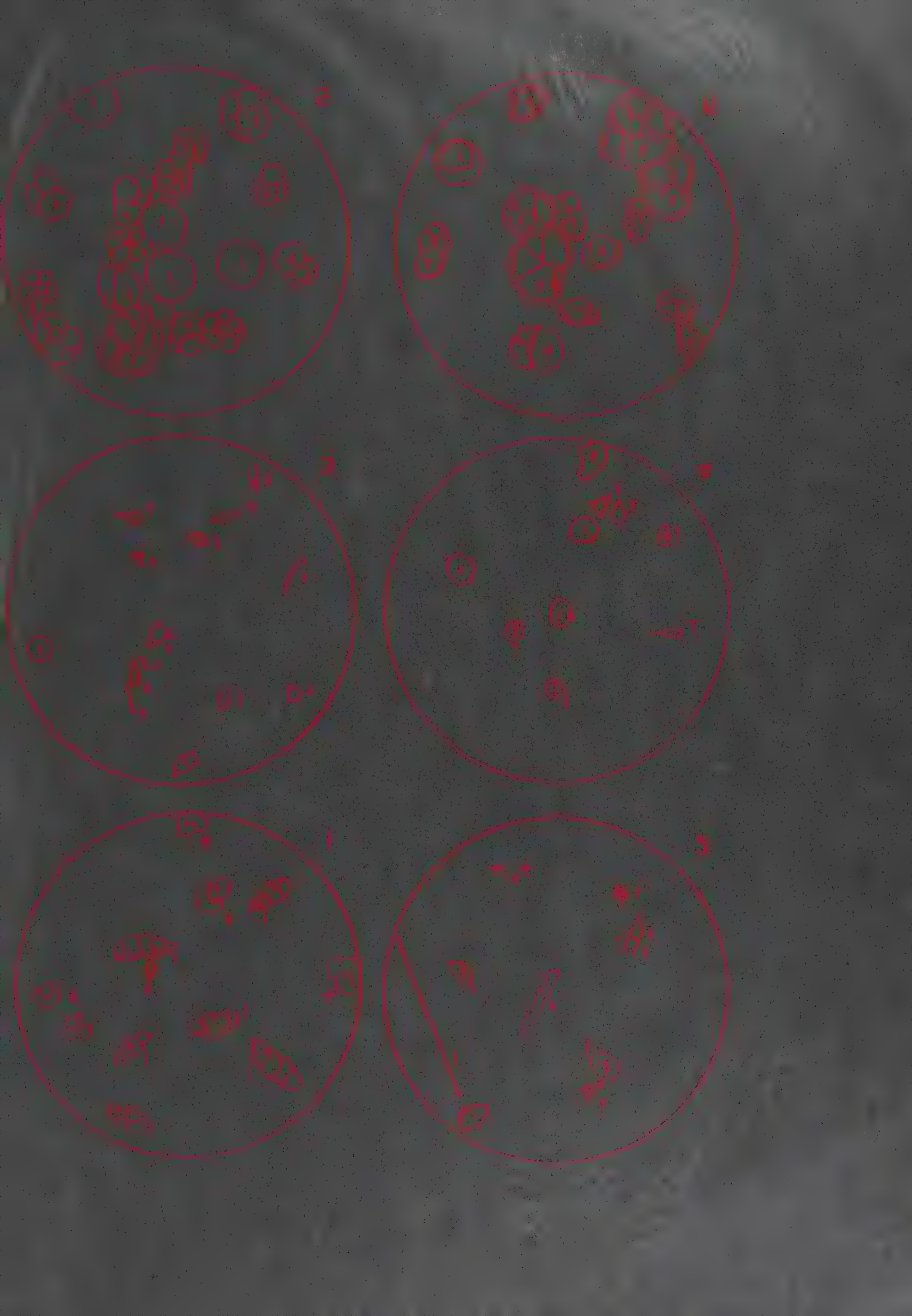

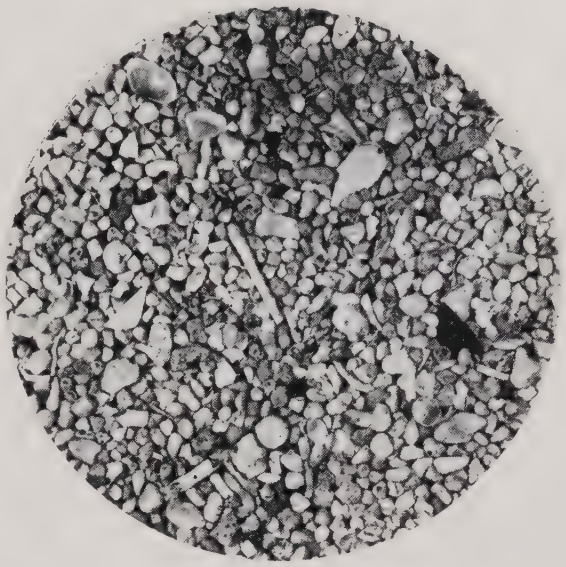

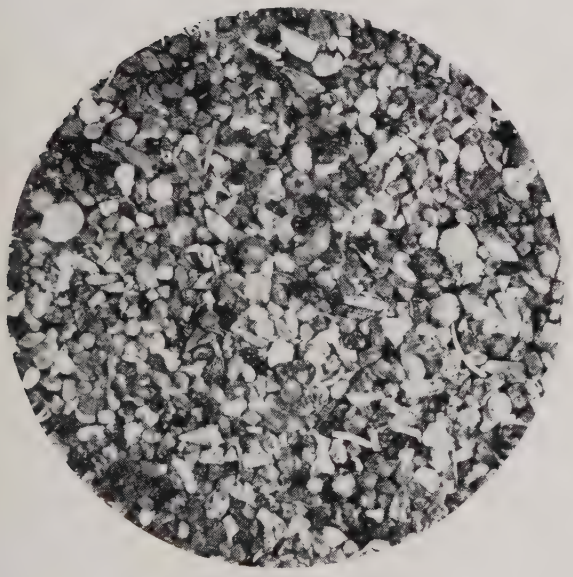

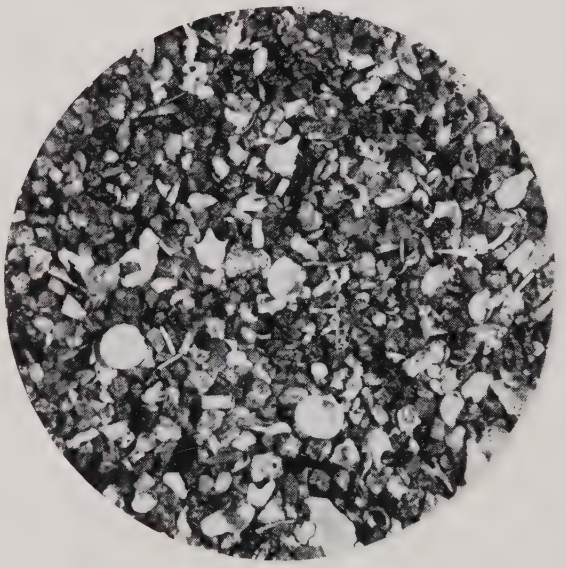

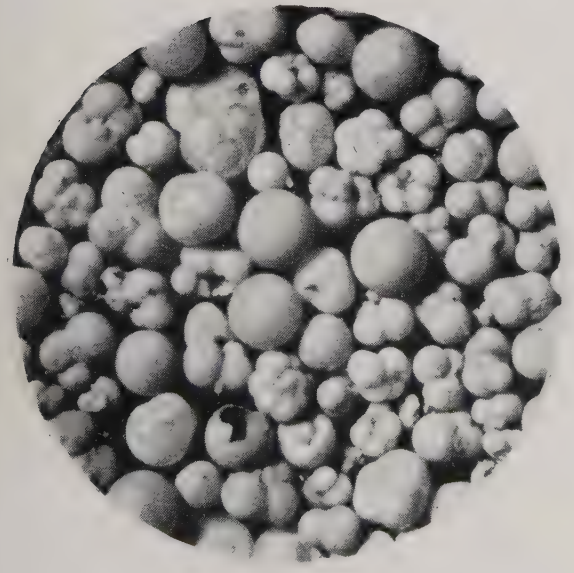

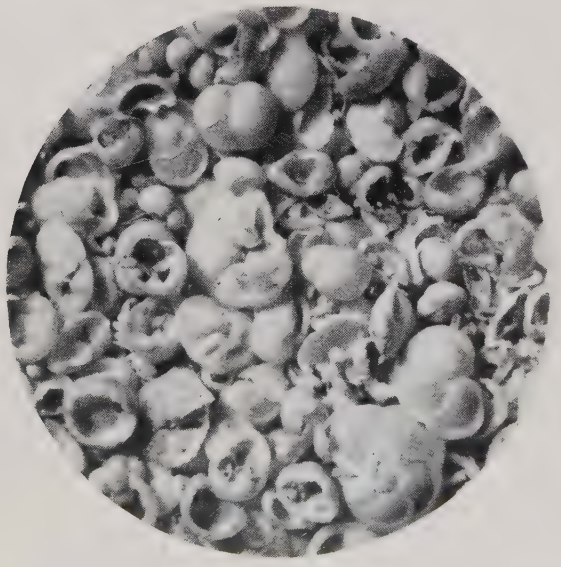

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DESCRIPTION OF PLATE III.

1. Pteropod Ooze, chiefly *Cavolinia longirostris* : Sta. 207, Red Sea, × 1.
    1. *Cavolinia longirostris* (Lesueur).
    2. *C. uncinata* (Rang).
    3. *Diacria quadridentata* (Lesueur).
    4. *Clio pyramidata* Linnæus.
    5. *Hyalocylis striata* (Rang).
    6. *Creseis virgula* Rang.
    7. *Cr. acicula* Rang.
    8. *Atlanta* sp.
    9. Lamellibranch valves.
    10. Gasteropod shells.
    11. Echinoderm shells.
    12. Fish scale.

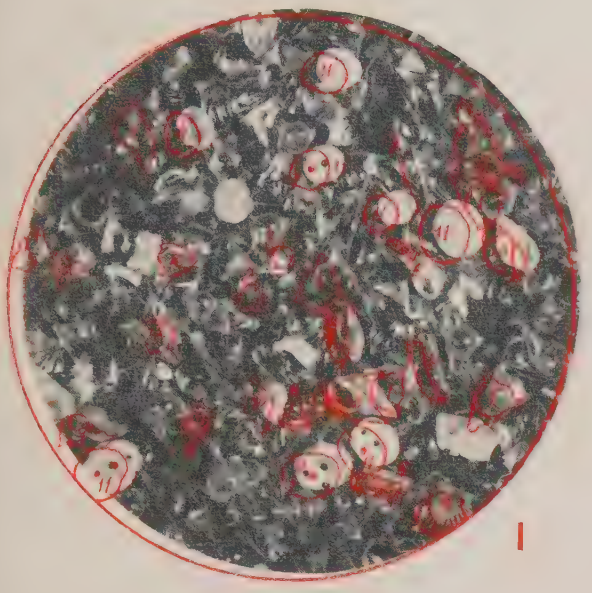
2. Pteropod Ooze, chiefly *Creseis* spp. : Sta. 75, Gulf of Oman, × 1.
    1. *Cavolinia longirostris* (Lesueur).
    2. *Diacria quadridentata* (Lesueur).
    3. *Creseis acicula* Rang.
    4. *Atlanta* sp.
    5. Lamellibranch valve.
    6. Gasteropod shells.
    7. Scaphopod shell.
    8. Echinoderm shells.
    9. Polychæt tube fragments.
    10. Crustacean fragments.

3. Coarse Coral Gravel : Sta. 139, Maldive Archipelago, × 1.
    1. Lamellibranch fragments.
    2. Gasteropod fragments.
    3. Scaphopod shell.
    4. Alcyonarian spicules.
    5. *Heterostegina* sp.
    6. *Placopsilina cenomana* d'Orbigny, on Lamellibranch shell.

4. Coarse Coral Gravel : Sta. 144, Maldive Archipelago, × 1.
    1. Lamellibranch valves.
    2. Gasteropod fragments.
    3. Echinoderm spine.
    4. Crustacean fragment.
    5. *Amphistegina radiata* (Fichtel and Moll).
    6. *Halimeda* sp.
    7. *Lithothamnion* sp.

5. Coral Sand : Sta. 163, Maldive Archipelago, × 15.
    1. *Limacina inflata* (d'Orbigny).
    2. *Atlanta* sp.
    3. Lamellibranch fragments.
    4. Gasteropod fragment.
    5. Polychæt tube fragment.
    6. Rotaliid Foraminiferan.
    7. *Amphistegina radiata* (Fichtel and Moll).
    8. *Globorotalia canariensis* (d'Orbigny).
    9. *Gl. menardii* (d'Orbigny).

6. Coral Mud : Sta. 142b, Maldive Archipelago, × 1.
    1. Lamellibranch fragments.
    2. Gasteropod shells.
    3. Echinoderm fragments.
    4. Crustacean fragments.



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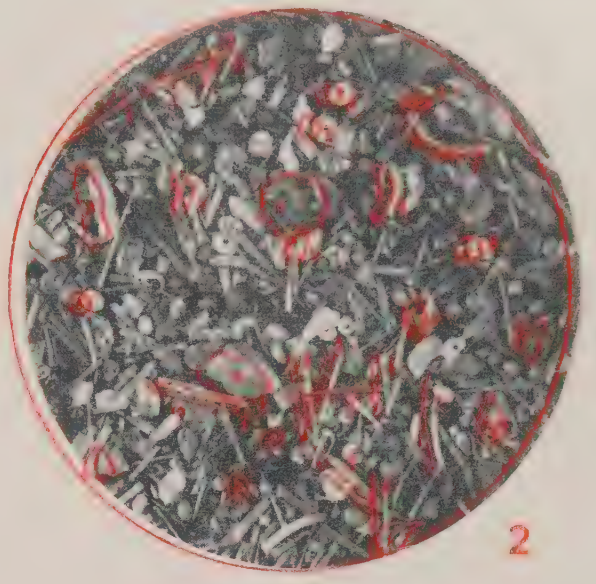

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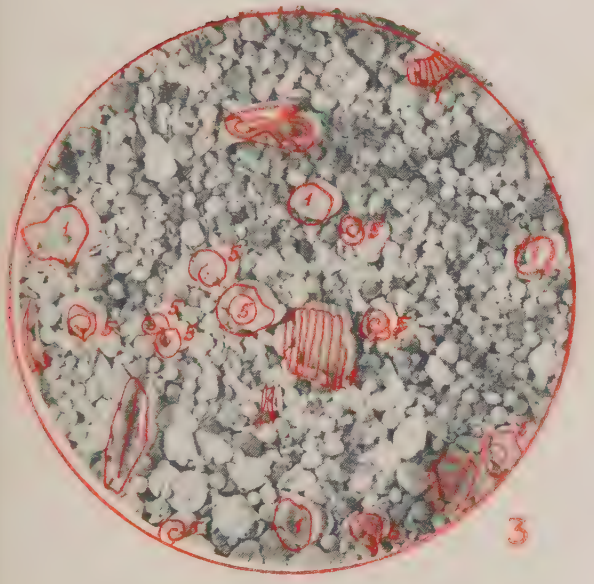

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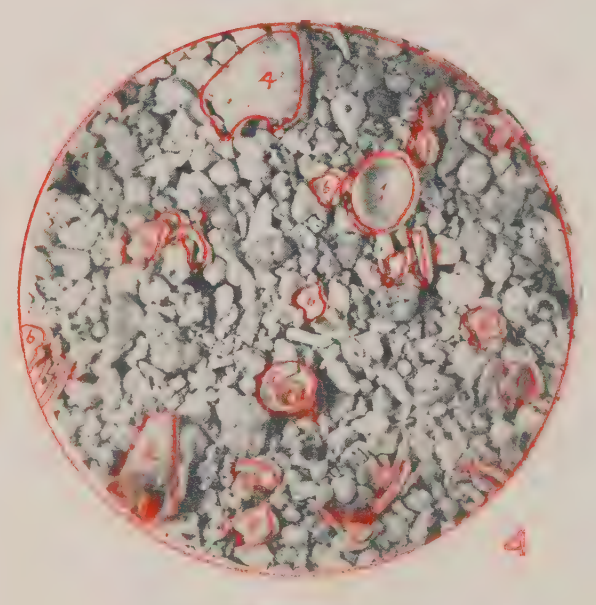

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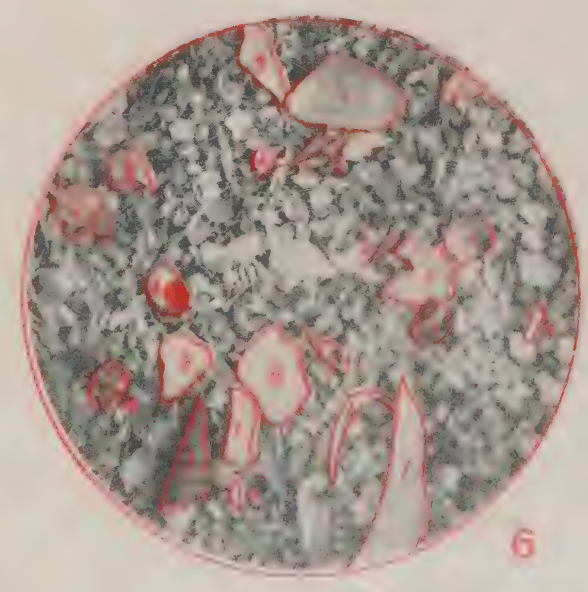

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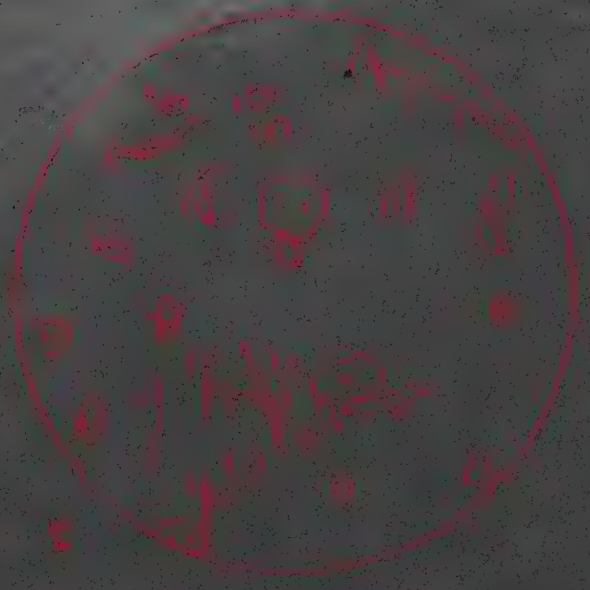
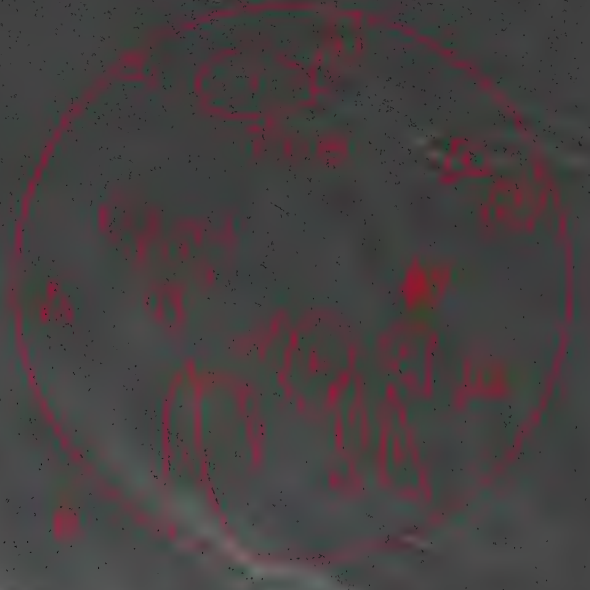
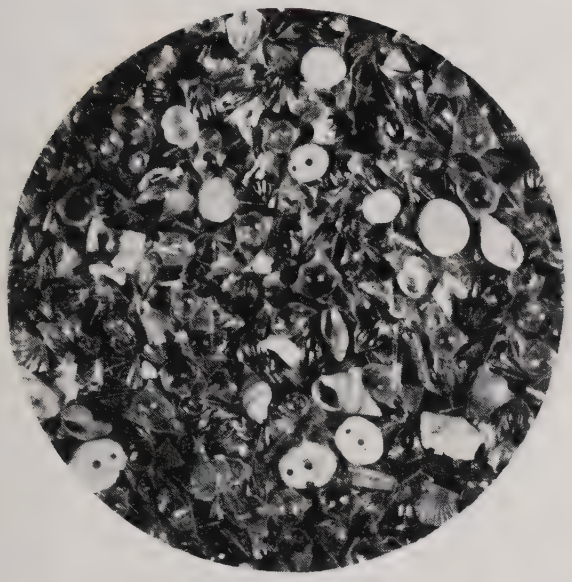
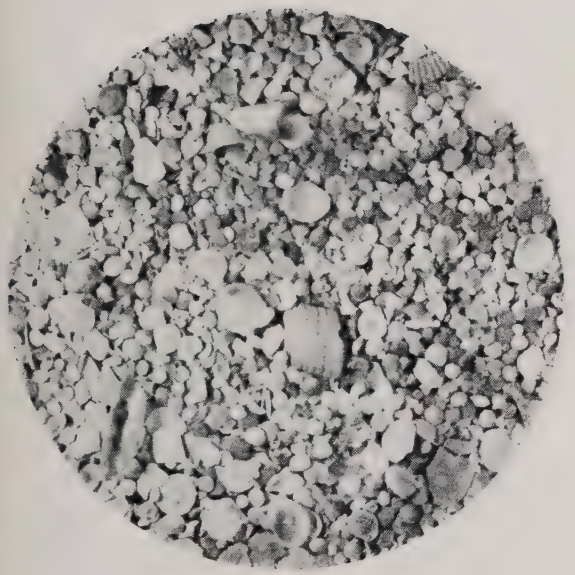
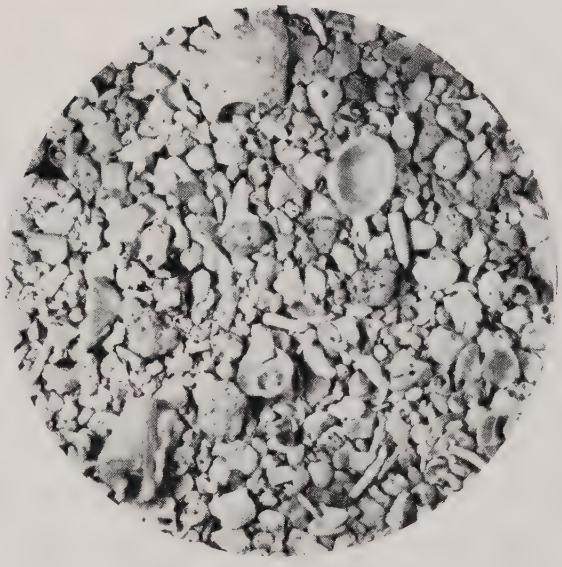






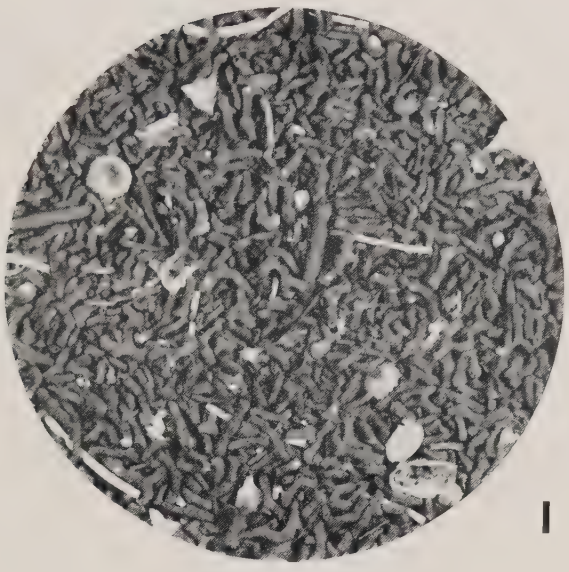




[*Adlard & Son, Ltd., Impr.*

DESCRIPTION OF PLATE IV.

1. *Dendrophrya ramosa* Cushman : Sta. 105, off Zanzibar, × 1.
2. *Rhabdammina abyssorum* M. Sars : Sta. 185, Gulf of Aden, × 1.



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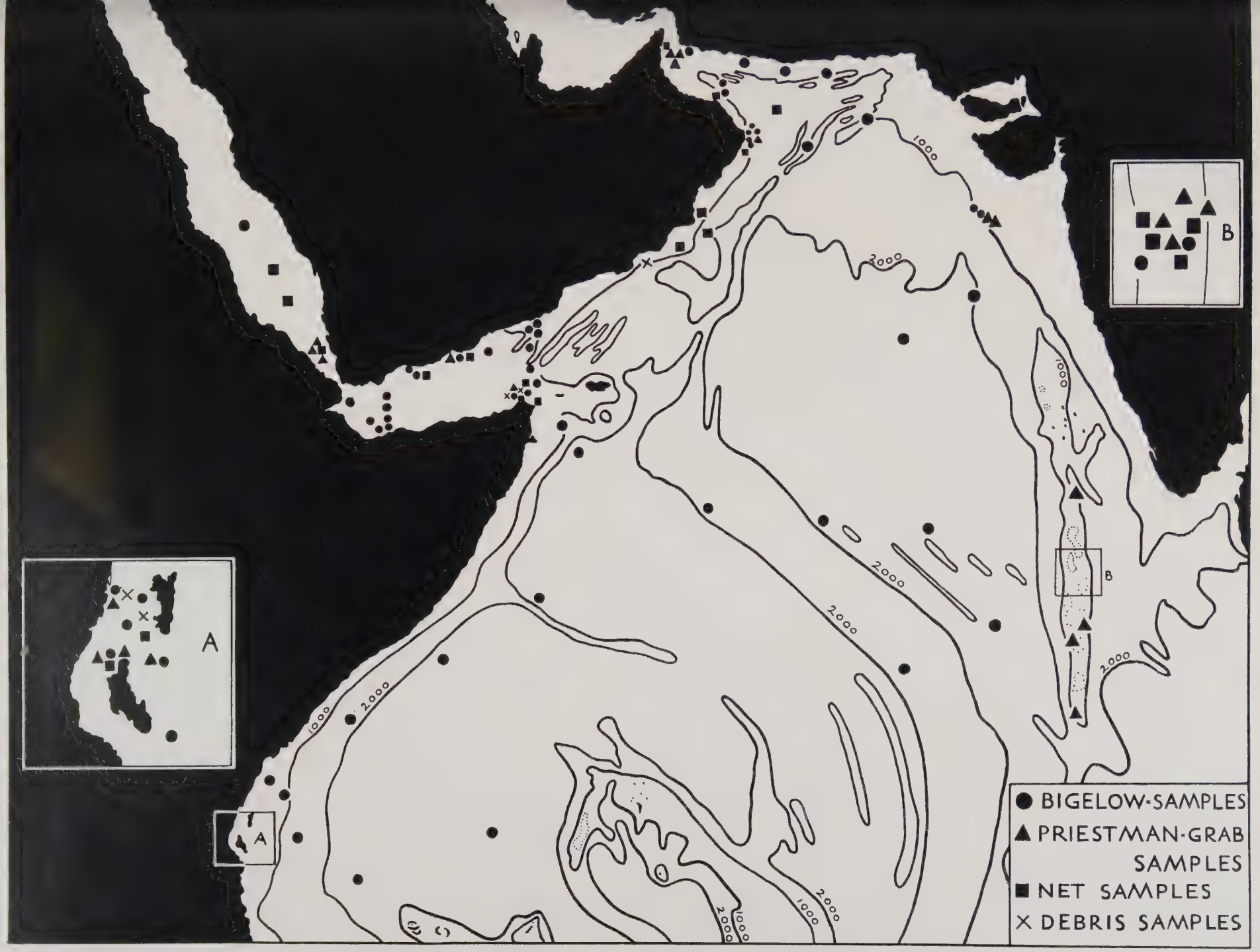
[*Adlard & Son, Ltd., Impr.*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PRIESTMAN-GRAB SAMPLES
NET SAMPLES
DEBRIS SAMPLES

CHART II.—The Ridges and Basins of the Arabian Sea

CHART III.—The Deposits of the Arabian Sea.

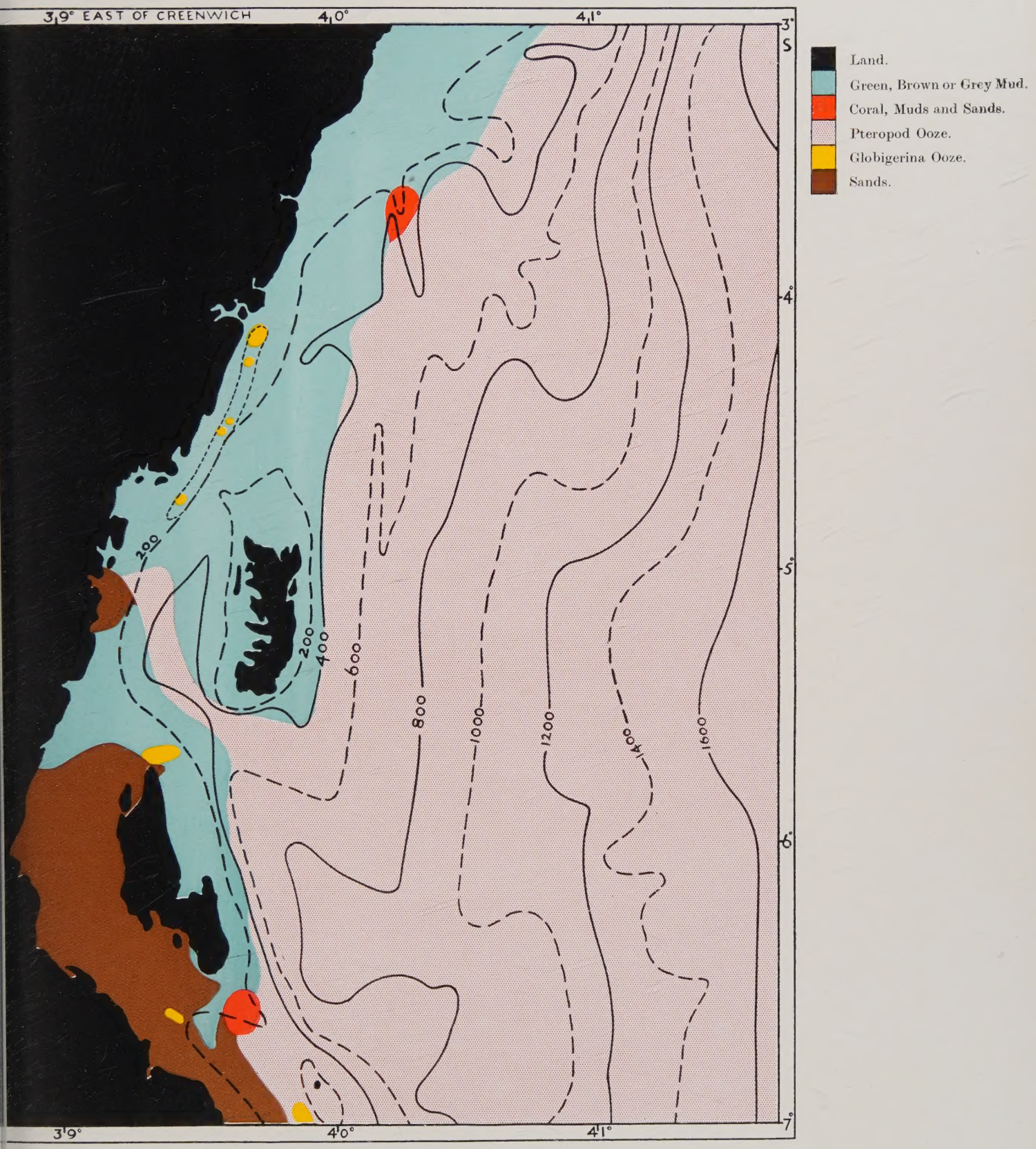

CHART IV.—The Deposits of the Zanzibar Region.